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DECEMBER, 1930

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

How to Study Chemistry
Geometry in Trigonometry
Agriculture in General Science
Procedures in Geometry and Algebra
Measurement of Textile Colors
Science Department Costs
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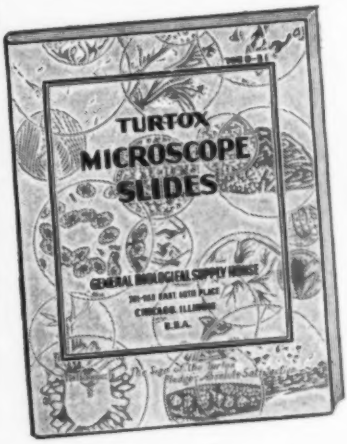

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXX NO. 9 DECEMBER, 1930 WHOLE NO. 263

THIRTY YEARS OF SERVICE.

With this issue the thirtieth volume of SCHOOL SCIENCE AND MATHEMATICS is closed. It is with a feeling of considerable pride that those who have edited and published the journal through this, the greatest period of educational and scientific progress in the world's history, can scan the inventory of the part it has had in this movement. Based on the number and value of articles published for high school teachers, or upon the frequency of reference made in leading publications to the reports published in these thirty volumes, as well as on its length of service, SCHOOL SCIENCE AND MATHEMATICS stands without a peer in the field of secondary education journals in mathematics and science. However, at this time it is not to the achievements of the journal that your attention is directed but to the service of one man on the editorial staff. Dr. George W. Myers may well be styled the Dean of our editors. He had a large part in putting out the first issue and has contributed actively to each of the succeeding volumes. He is the only member who has been on the staff from the beginning.

Early in his teaching career Dr. Myers recognized that the necessary foundation for any kind of a mathematical career, whether it be research in pure science, applied mathematics, the teaching of mathematical subjects, or any other career dependent upon mathematical principles, is a working knowledge of the basic principles and considerable skill in the elementary processes. Much of his time has been devoted to pointing out to teachers

these important factors and in showing how to master the theory and attain the skills. He is a great educator who is big enough to keep in view the elementary principles. Officially he closed his teaching career nearly two years ago; actually he continues teaching not only thru his published books and contributions to educational journals but by an active part in the councils of teachers. In this issue it is our privilege to offer you one of his latest contributions. During this year he will act as a counselor to the Research Committee of the Men's Mathematics Club of Chicago.

WHAT IS A PRACTICAL SCIENCE COURSE?

Practical is the magic word that has sold textbooks in chemistry, algebra, physics and other sciences. Teachers have sold their services to superintendents by demonstrating their abilities to give practical courses, and administrators have obtained increases in funds because the schools were made practical under their leadership. To teach the applications of science is commendable; to make science education carry over into daily life is excellent; to establish scientific habits of thinking and living is the real goal of science instruction.

The big problem is how to realize this aim. The applications of science are legion. It is impossible even to mention many of the practical uses of the fundamental principles of science as they are studied. In the secondary school science should not be taught as a vocational subject. Adaptability is a more valuable attribute than great skill in a limited field, even for the student who must drop out of school at eighteen. The industries and arts are not perticularly anxious to employ great numbers of ready-made experts. They prefer to take people who have learned to think clearly along basic principles, and give them the limited technical training needed while they are on the probationary period of their employment. For the young man or woman who has the ability and the means to complete a high school or a college course, the most practical course is that which gives a thoro education in basic principles.

Practical must not be confused with spectacular. Lecture demonstrations are often such successful entertainments that real education does not even appear as a by-product. Interest is a fundamental prerequisite for effective learning, but it must be focused on the idea to be learned, not on some complicated device or structure that conceals the main topic of study. Teaching applications is of little value unless it results in emphasizing and clarifying the scientific principle involved.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,

The University of Oklahoma, Norman, Okla.

Hundreds of people in Europe (as elsewhere) are trying to protect the pedestrians from motorists; only one, that I know of, ever thought of the radical measure which alone would compel the motorist to slacken his speed: take away his Klaxon from him.—*Ernest Dimnet, "The Art of Thinking."*

In association with its context, nothing is more impressive or instructive than a fit experiment; but, apart from its context, it rather suits the conjuror's purpose of surprise than the purpose of education which ought to be the ruling motive of the scientific man.—*John Tyndall, "Lectures on Light."*

Observe me, Sir Anthony. I would by no means wish a daughter of mine to be a progeny of learning; I don't think so much learning becomes a young woman; for instance, I would never let her meddle with Greek, or Hebrew, or Algebra, or Simony, or Fluxions, or Paradoxes, or such inflammatory branches of learning; neither would it be necessary for her to handle any of your mathematical, astronomical, diabolical instruments. But, Sir Anthony, I would send her, at nine years old, to a boarding-school, in order to learn a little ingenuity and artifice. Then, sir, she should have a supercilious knowledge in accounts; and as she grew up, I would have her instructed in geometry, that she might know something of the contiguous countries; but above all, Sir Anthony, she should be mistress of orthodoxy, that she might not misspell, and mispronounce words so shamefully as girls usually do; and likewise that she might reprehend the true meaning of what she is saying. This, Sir Anthony, is what I would have a woman know; and I don't think there is a superstitious article in it.—*"Mrs. Malaprop" in Sheridan's "The Rivals."*

I never come across one of Laplace's *"Thus it plainly appears"* without feeling sure that I have hours of hard work before me to fill up the chasm and find *how* it plainly appears.—*Bowditch, the translator of Laplace's "Méchanique celeste."*

AUXILIARY PROCEDURES FOR INCREASING INHERENT INTEREST, MOTIVATION AND INDIVIDUAL EFFICIENCY IN GEOMETRY AND ALGEBRA.*

By George W. Myers,

University of Chicago.

Teachers of high school are no longer ashamed to attempt to interest students in their mathematical studies. They are willing to tax their students' mathematical aptitudes and abilities to a degree, because they have learned that the surest route to a sustained interest in mathematical study lies through taxing the students' abilities. This has not always been the case even during my short memory. The doctrine of interest as a teaching aid has however pretty fully won its way in the secondary field, even including the mathematical domain.

In fact efficient teachers now quite generally hold the sane view that interest on the part of students in their work has the same office in the school life of young people that happiness in his life work has to the adult man of affairs. Happiness in the work of one's vocation is not absolutely necessary to a measure of success in the pursuit of his calling, for surely there are all too many who do not find happiness in the discharge of the routine of their callings. From their conversation many would seem to be drudging fifty weeks of the year for the two weeks of vacation. Perhaps they are the mere wage and salaried workers and their name is legion. We have sometimes been fearful that some of the unhappy ones have gotten stranded at least temporarily in the teaching profession. But for the fullest measure of success in one's calling a liberal measure of happiness in its pursuit seems essential. One can hardly master mathematics under the salaried-worker attitude. He must work under contract here and take it by the job.

Most of us I think, will approve Professor Josiah Royce's way of putting this matter. On Jan. 20, 1916, while speaking on "The Duties of Americans in the Present War" he had this to say: "I have a right to happiness solely because a certain measure of happiness is needed to adapt me to the work of a man. I have a right to possess some opportunity to fulfill the office of a man." The right-minded teacher will

*Delivered at the October 24 meeting of the Chicago Men's Mathematics Club.

concede to his algebra or geometry student the analogous claim: "I have a right to interest in my school work solely because a measure of interest is needed to adapt me to the work of a student. I have a right to possess some opportunity to fulfill the office of a good student." Not only do good teachers of mathematics in high school now hold this view of the function of interest, but they also very generally practice it in the class room.

The particular type of interest that is of sustained value in mathematical learning is that interest which inheres in the particular subject in hand. In algebra and geometry the interest that is effective and enduring is interest in these studies themselves and not in more or less remote collateral issues, even of practical applications. Of course in the beginning stages of study of these branches, while the student yet knows so little of the spirit and nature of the new disciplines as to render him incapable of judging of their significance and worth, extraneous interests in the utilities of the specific studies must be resorted to even frequently. The greater the incompetency of the mathematical learner the more generally and frequently must resort be had to early applications and utilities to arouse and steady the concern for the algebra, or the geometry. But in so far as the algebra teacher fails at no late stage to turn the learner's interest into algebra as algebra in just that far is he not likely to succeed as an algebra teacher. The same goes also for geometry.

It is therefore my intention to speak briefly of ways and means of arousing and sustaining interest in algebra as algebra, or in geometry as geometry and to confine my remarks to certain aspects of technique or procedure which I find arouse interest, facilitate the conversion of the utility into scientific interest and also tax the individual ability of the student. This is the aspect of educational activity that I have been intensively concerning myself with for the last few years and I have felt that if you did not care to hear about it you would not have asked me to address you. Just keep in mind that I am merely telling you of things you might with considerable labor do for your own teaching, and which I think ought to be done for it somehow, and that I am not wanting to be regarded as a salesman of my own

wares amongst you, even though I have been instrumental in getting most of them in available published form. It perhaps does not need to be said to you that some pretty phlegmatic people had to be convinced of the desirability of these techniques before they could reach the stage of publication. The aspects of procedure that I wish here to draw to your attention are of wide and easy applicability in the class room. I will begin with aspects of teaching procedure for geometry.

The leading indictment against the teaching of algebra and geometry in high schools of today is not that teachers are not generally conscious of approved educational objectives for their teaching, but rather that they do not generally attain the set objectives to any considerable degree. A most important immediate problem before teachers of these subjects is to devise ways of measurably achieving the set objectives, and through such procedures as will render this achievement evident and convincing to the skeptical.

I. *A First Auxiliary Technique.* For the successful study of algebra or geometry we all know that some things need to be much better learned than others. Those fundamental notions and processes that are most frequently needed in subsequent work must be gotten well beyond the threshold of consciousness, i. e. they must be well mastered. They must be mastered to the degree of becoming so easily recallable that when a need for them arises the learner may quickly sense that the situation in hand requires some particular one or ones of them, and that he may avail himself of it or them in correct form without too greatly distracting his energy from the main issue at hand. These basic elements in both algebra and geometry should be thoroughly canvassed, set out for special and frequent emphasis and equipped with appropriate practices and drills. Welte in a doctorial dissertion at The State University of Iowa has done the first part of this service for plane geometry.

Let me illustrate the substance of what I have just been saying by exemplifications from plane geometry, because it is the mathematical study with reference to which general professional opinion is that there is in it little or no need for drill.

I am claiming that there is need in geometry classes for

—(1) Rapid work stressing often crucial basic geometrical facts, (2) Practice work summarizing such knowledge in organized fashion, and (3) Drills calling for critical thinking in applying such knowledge in problem situations.

A group of high school teachers and educational specialists undertook in the recent past to see what they could do for the teaching of plane geometry along aforesaid lines by formulating techniques for—

1. Short oral drills for the entire class on the fundamentals of geometry, after having painstakingly canvassed the groups of principal and subsidiary theorems of The National Committee on Mathematical Requirements for these fundamentals, and having listed them with their frequencies of occurrence in the proofs of other subsequent theorems.
2. Rapid written group drills on these same fundamentals in appropriate settings.
3. Diagnostic and remedial work on these fundamentals.
4. Reviews that are at the same time tests of achievement on crucial points of the day's, week's, month's, semester's, or other unit's work.
5. Competitive games based on exercises involving items of the list of fundamentals.
6. Exercises in geometrical description.
7. Cumulative reviews for whatever objections the teacher may have in view.

After some work along these lines the group of workers discovered that Miss Ruth O. Lane, head mathematics teacher in the experimental high school of the State University of Iowa, had been using with marked success a set of rapid drill cards on plane geometry of her own making through a year or two, and with about the same purposes in mind as those actuating the group, and she was asked to join the group of workers. After another year's experiment and improvement of the cards with prime regard to easy classroom practicability, the *Geometry Rapid Drill Cards* by Lane, Knight and Ruch were published—there are 143 of them in the set covering only plane geometry—and they are now available commercially for teachers who believe in their purposes and values and who cannot or do not find the time to make their own equipment.

The cards have met with good sales since their appearance Oct. 1, 1929, and to witness to their usability and effectiveness I offer a few testimonials from actual users of them. The cards have been found generally interesting, stimulating and taxing to individual abilities of students. I regard this auxiliary device as one of the most generally helpful that has come to geometry teaching in a long time. It is a great labor saver for the busy teacher. A very large percentage of the cards involve the "Yes-No" type of response and incidentally, they exemplify how one of the modern refined techniques developed for testing purposes, may be converted into an effective teaching and learning technique.

As this flash card device common enough elsewhere, is a rather distinct departure in class room technique for geometry, you may be interested to know what actual users of the device say about it. I therefore include here five brief testimonials from last year's users.

I. Several cards were laid on the teacher's desk before the class entered and a pupil was asked to begin showing the cards as soon as the buzzer sounded for the beginning of the hour. Meanwhile the teacher took the roll. This time, formerly often lost, was saved and discipline was made easier. All the class seemed interested in the use of the cards. I found the class was accomplishing more in the three to five minutes' time in which the cards were issued than during any other five minutes of the class period. Ruth O. Lane, U. of Iowa High School, Iowa City, Iowa.

II. The principal use we found for the Geometry Rapid Drill cards was to clinch the day's work and give a rapid review by using the last five or ten minutes of each period. They were also occasionally used for longer drill periods. Sometimes the teachers hung a dozen of them on hooks around the room and used them for a written test of the objective type. We are much pleased with them and consider them a good investment. P. S. Remington, Chairman Mathematics Department, St. Louis, Mo.

III. I am delighted with the work accomplished this year in my geometry class and I attribute it largely to the use of the Rapid Drill Cards. I kept them handy and used them at every odd minute. The class liked them very much and interest always picked up when I picked up one of the Drill Cards. Ethel Kirkpatrick, Richmond, Mo.

IV. The Geometry Drill Cards are a very great time-saver. I used them for final examination, for reviewing, testing, diagnosis, etc. The additional questions on each card are helpful. John A. Reed, Iowa City, Iowa.

V. I have had our Geometry Rapid Drill Cards for about two months. I am delighted with them. I found them particularly helpful in the review work at the end of the term. Katherine Fowler, Jno. Adams Senior High School, Cleveland, O.

II. *A Second Auxiliary Technique.* Teachers of high school algebra and geometry are quite given to pointing accusingly to antecedent pedagogical deliquency for the shortcomings of pupils that are always revealed in the early stages of these subjects. It has long seemed to some that it would be a real aid to the teaching of first year algebra and geometry to have a carefully and competently selected body of auxiliary material for each of these subjects, designed and organized to assist the teacher in accomplishing the following educational ends:

1. Reviving and vivifying certain essential beginning notions, basic vocabulary items and principles, which are commonly supposed to have been sufficiently mastered in earlier courses for the needs of these courses, but which are commonly found to be mortifyingly troublesome through long periods of the earlier stages and which delay both class and individual progress to such an extent as to set a low level and a needlessly slow pace of accomplishment. This *desideratum* we have sought to accomplish through five or six preliminary lessons closely related to the work of standard texts, in both first-year algebra and plane geometry.

2. Calculated reviews of experimentally determined essentials in the form of standardized self-test drills to be used once a week in close association with textual assignments, both to combat the inevitable rapid forgetting that must come in accord with the psychological law of forgetting however effective the teaching may be, and to provide reliable weekly measurements of progress through standards based upon nation-wide exposures and scores. This obviously enables the teacher to avail himself of a most powerful motivating device resting directly on the psychological principle of awareness of success or failure at the moment of learning, since the drills for review are made both self-scoring and self-rating.

3. A corrective technique for immediate detection and correction of errors to forestall the wide-spread and vicious practices of training in error, of habituating the erroneous.

4. Related specific difficulty and error studies and Remedial Work coming through five or six Disucssion Units following each group of five or six drills and based upon the findings of these drills.

5. The plotting by the pupil himself of his own scores on first trial of the review drills on a systematically kept Progress Chart. Thus he is in continual competition with his own past achievement, and this is turning to class-room use a principle of motivation of no mean value.

All these five specific types of study work and teaching aid we have organized into 30 units to accompany any good standard text and to be used as mentioned above at the rate of about one a week through the year, and we have called the organized bodies of material *The Standard Service Geometry Work Book* and *The Standard Service Algebra Work Book*, the former by Welte and Knight published October, 1929, and the latter by Knight, Ruch and McCulloch published October, 1930. With each Work-Book there is a pupils' edition and a teachers' edition, the latter being supplied with devices for recording class performance and progress and for supervisory uses.

The complete Work-Book serves the double purpose of being: (1) a very carefully organized body of home-work for pupils, and (2) a motivating, measuring and supervising agency for the teacher.

Do you ask what all this has to do with our slogan: "Interesting to the pupil and within the range of his ability?" Let me answer.

In a school that used the Geometry Work-Book last year, after an inquiry by the principal as to how the Work-Books were taking with pupils, a teacher asked her pupils to write down for their principal and without signing their names, what they thought about the Work-Books. Here is what they wrote:

1. They help me to remember by constant review.
2. They develop accuracy.
3. They help one to develop quick thinking, due to the time limit.
4. They help one find his weak points.
5. They help one in learning to apply what he has learned.
6. They emphasize salient points.
7. They cause one to depend on himself.
8. They are an incentive to work harder.
9. They are interesting.
10. They help one to understand better and easier the new matter of the text book.
11. They aid the student in correcting his own mistakes.
12. They provide means of letting the student know where he stands with respect to other students.

From teachers the testimonials are uniformly and strongly favorable.

That the Work-Book device is pertinent to our consideration here will I think, be readily granted, for the reason that it has been objectively shown to be both interesting and within the ability-ranges of pupils. The members of this Men's Mathematics Club are broadminded enough to realize that my argument here is not that of a salesman of my own wares, but rather that the type of auxiliary matter that I have advocated above can be and ought to be made and used by algebra and geometry teachers, that teachers can with considerable expenditure of time and labor make such material for themselves, but that rather than deprive their pupils of its benefits some of you might care to avail yourselves of our labors in these directions, for they are available commercially at almost a nominal cost.

Space can be spared here for but a single testimonial as to the values of the Work-Book for geometry. From Miss Emily Shoup of Marshall, Mich., comes this word:

"The books have given me a feeling that I share with the students, that of accomplishment and knowledge of the degree of accomplishment. It gives the teacher some satisfaction to know that her students are reaching a standard which compares favorably with that of other geometry students. Besides these things the Work-Books offer a means of finding weaknesses and difficulties. In making the diagnostic record which is provided for in the teachers' edition of The Work-Book, I am able very easily to find the facts which need further information. I am also able to provide individual help for those who have failed on some item which is familiar to the majority. The charts which I keep from these diagnostic records show that the class rating is gradually increasing. This increase I feel is not due to a familiarity with the specific types of exercise, but to a gradual accumulation of knowledge and ability to apply that knowledge. This latter fact alone would justify in my mind, the expenditure of the time and money on the books."

Other testimonials are plentifully available if wanted, but I do not want to tire you out.*

III. *Some Appropriate Research Studies.* In conclusion, let me list some worthwhile questions to one or more of which the Chicago Men's Mathematics Club might well devote research activity and to which special study and discussion in club conferences would most surely lead to in-

*Scott Foresman and Co., 623 So. Wabash Ave., Chicago, are the publishers of both Work-Books and also of the Rapid Drill Cards alluded to above. Further detailed information on the techniques will be gladly furnished by the Company.

teresting outcomes within the ability ranges of high school pupils.

1. Formlate through club discussion and determination a short list of approved, competent and leading objectives for the several high school courses of high school mathematics and organize teaching procedures for definitely achieving the objectives by the aid of techniques which measure objectively the degree of success or failure in attaining the set objectives while revealing to the pupil his own success or failure in mastering the individual units of the courses.
2. Constructing scientifically valid and reliable remedial and reteaching procedures for the several high school mathematical subjects, with exemplifications of sample treatments of chosen typical units of work.
3. Error Studies with Appropriate Remedies—Collecting in actual class-work of errors made repeatedly by learners with prescriptions of appropriate remedial treatments of error-types derived from the intensive and extensive canvass of the errors actually collected.
4. Formulation of a generally useable skill-maintenance program for each high school mathematical course.
5. A teaching program for motivating mathematical study through a plan of keeping the pupil aware from week to week of his successes and failures in specific items of the work of the course.
6. Canvassing the several mathematical subjects for those basic ideas and notions that are the "working-linkages" out of which propositions, theorems and theories are built, tabulating the frequencies of subsequent use of these "linkages," with the view to building valid, proportionate and focalized practices and drills upon them. Distributive, proportioned drills, moderate in amount, and in which objectively efficacious outcomes are the promised results.
7. Construct and standardize in the Chicago area appropriate drill units based upon the revealed "working-linkages" alluded to above, providing for each elemental linkage drill occurrences proportioned to its frequency and difficulty.
8. Formulation of definite techniques for starting the year's course right.
9. Procedures for utilizing refined testing techniques transformed into appropriate learning techniques and study techniques.
10. Develop a workable technique for fostering and teaching problem-solving in algebra and in geometry.
11. Formulate an objectively useable technique for teaching Study Habits.
12. A meeting now and then might well be given to reviews and reports on valuable professional contributions and publications with club discussions and criticism.

The foregoing twelve subjects are of course only a start on the fields of research the Club might devote itself to, but any one of the foregoing would in the progress of work upon it, be sure to develop into a dozen or more related questions worthy of the Club's united efforts.

In 1818 petroleum was first discovered. In 1859 the first well was sunk and 2,000 barrels of crude oil recovered. In 1861 our annual output was 2,000,000 barrels. In 1926 the United States produced one-half billion barrels or two-thirds of the total production of the world.

THE MEASUREMENT OF COLOR AND LUSTRE AS APPLIED TO TEXTILE FABRICS.*

By Assistant Professor A. Edwin Wells,
Engineering Department, Lowell Textile Institute, Lowell, Mass.

Theory.

When light falls on materials such as paper, enamel, silk, etc., regular, diffuse, and spread reflection occur. The theory of these types of reflection is well summarized in the following extracts from Kunerth's Illumination.

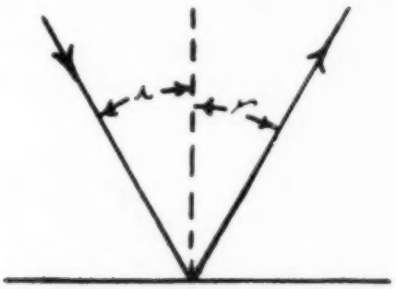

Figure 1

"*Regular reflection.* The law of regular reflection states that the angle of reflection is equal to the angle of incidence. In Figure 1 i is the angle of incidence and r is the angle of reflection. All of the reflected light travels in the same direction. Illustrations of this type of reflection are found in mirrored glass and polished metallic surfaces.

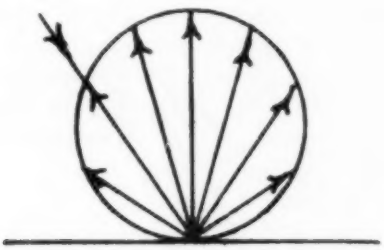

Figure 2

Diffuse reflection. Figure 2 illustrates the law of diffuse reflection. In that case the light is distributed in all directions independent of the angle at which the incident beam strikes the sur-

*This paper was presented at the May, 1930, meeting of the Eastern Association of Physics Teachers. Apparatus, built as suggested by the theory, was demonstrated using textile fabrics.

face. Whatever this angle, the maximum flux of light is reflected normally to the surface and there is some light spread through an angle of 180° as shown in the figure which represents a photometric curve of the light reflected from a small portion of a perfectly diffusing surface. Considering that this light is reflected in three dimensions, this curve is really a section of a sphere. This spherical distribution obtained with diffusely reflected light is determined by the cosine law, which when applied to this case means that the intensity of the reflected light at any angle from the normal to the surface is proportional to the cosine of the angle.

Objects are seen by means of the light which they reflect diffusely and we see only by the light reflected diffusely to our eyes.

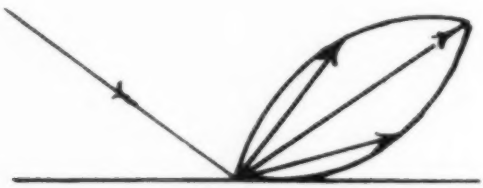

FIGURE 3

Spread reflection. Figure 3 illustrates a case of spread reflection. The maximum intensity of the reflected light is in the same direction as in regular reflection but part of the light is spread from its direct path as shown."

The following conclusions result from the above extract. For fabrics the resultant reflection will be a combination of the

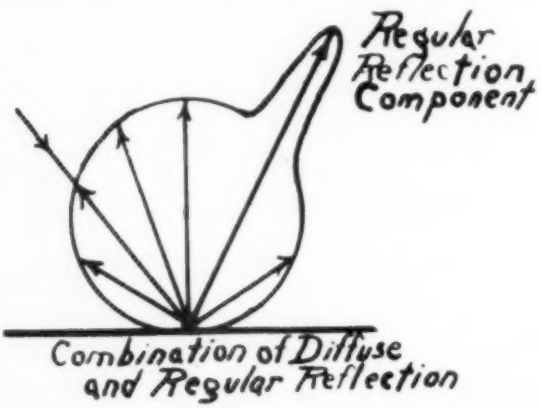

FIGURE 4

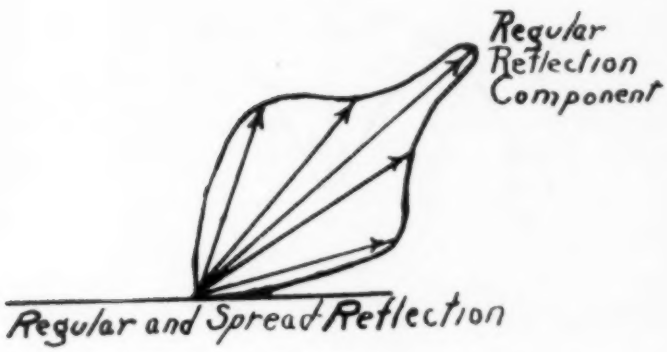

FIGURE 5

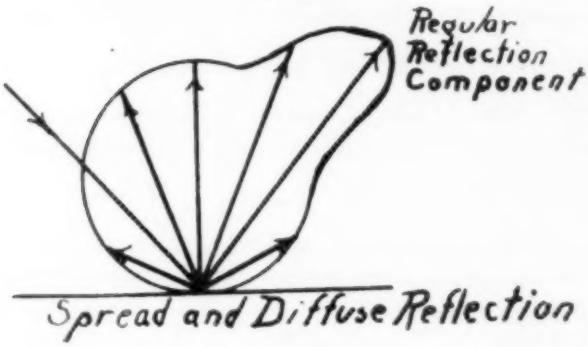

FIGURE 6

three types above mentioned. That is, the result should be similar to figures 4, 5 or 6. These are distribution curves and therefore are in candle power units.

The important point in this theory and in fact the basis of future research lies in the fact that each curve has a regular reflection component. As the distribution curves are in candle power units and the illuminometer reads in terms of intensity or brightness a study of the relation between the two is necessary. This relation between brightness and diffused reflection is shown by Lambert's cosine law quoted from Houston's "Treatise on Light." Lambert's law is derived as follows: In Fig. 7: "Let MS be a section of a surface and let i be the angle which the incident light makes with PN, the normal at P. Let I be the intensity of the incident light i. e. the quantity of energy received per square centimeter per second. Then if a straight line PQ be drawn of length r, making an angle e with PN and not necessarily in the plane NPM and an area dS be isolated on the surface of the wall at P, the intensity of the radiation from this area

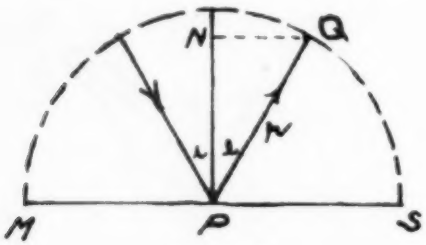

FIGURE 7

received at Q is $\frac{cI\,dS(\cos i)(\cos e)}{r^2}$ where c is a constant. This expression is known as Lambert's cosine law of diffuse reflection.

According to Lambert's law, the quantity of light received at Q per unit of area at right angles to PQ is $\frac{cI(\cos i)(\cos e)}{r^2}$. Owing to its being seen obliquely the surface dS appears at Q to have the area $dS \cos e$. The surface dS has thus the apparent brightness: $\frac{cI \cos i}{r^2}$ which is consequently independent of angle e. This is the physical basis on which Lambert's law rests. If the eye is moved around the dotted circle in figure 7, dS appears equally bright always. In other words the brightness of a surface is the same for all angles and the illuminometer readings on a diffusing surface should be constant. The apparent brightness of the different elements of a surface is the same no matter what angle the normal to the element makes with the straight line joining the latter to the eye. The radiation from an element of the surface in a direction making an angle e with the normal to that element must consequently be proportional to *cosine* e. Hence the candle power varies directly as the cosine of the angle.

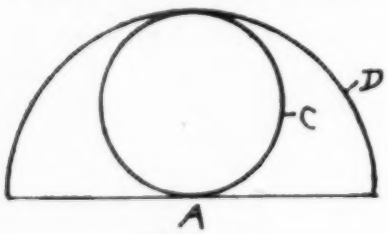

FIGURE 8

In figure 8 curve c represents the candlepower in various directions from surface A and curve D the brightness from the same surface."

This study of Lambert's cosine law shows that the illuminometer readings should be constant at all angles for diffuse reflection. For the types of reflection indicated by figures 4, 5 or 6 the brightness measurements are not constant. As an example the regular reflection component of figure 4 would produce a departure on the brightness curve as shown in figure 9.

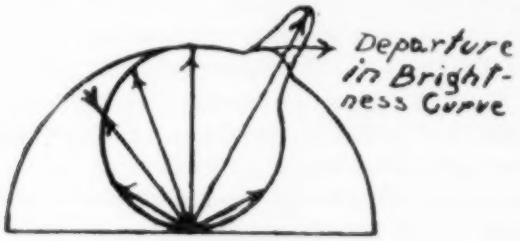

FIGURE 9

Reflection data for a number of fabrics shows that the brightness readings are not constant. The results indicate a departure similar to that of figure 9. A further analysis and study of luster is essential.

Luster is regular reflection. In other words the nearer a surface approaches that of a mirror the greater is its luster. This leads to the conclusion that a mirror is the best present example of luster. A mirror gives regular reflection as indicated in figure 1.

Therefore, the greater the luster the more pronounced should be the regular reflection component which is present in figures 4, 5 and 6. In other words the regular reflection component is an indication of luster.

As would be expected the regular reflection component is at an angle equal to the angle of incidence.

From these facts the following theory was developed. Place a light source, focussing a parallel beam of light on the fabric, at a stated angle of incidence. Then a brightness reading would be obtained by placing the illuminometer at an equal angle of reflection. This reading would be a measure of the regular reflection component. Keeping the angle of incidence fixed, and reading the illuminometer at other angles would give a measurement of diffused light. The ratio of the regular reflection component to the diffused light should be a measurement of luster.

This is substantiated by the following quotation from Kunerth's Illumination. "Objects are seen by the light which they

reflect diffusely. If one had perfect regular reflection one could not tell the presence of that body." Suppose two samples A and B are gauged with the naked eye for luster by being held in the plane of the incident light. It is decided that A has more luster than B. However, when the two samples are held in another position B produces more diffuse reflection than A and is more visible than A in the new position. This really proves that A is more lustrous because it is less visible in this position. For a mirror, which is the best example of luster, the ratio of the regular reflection to the diffused reflection, would be a maximum. Hence, additional apparatus should be manufactured for controlling the angles of incidence and reflection.

At a later date this theory received strong support through the following extract from A. H. Pfund's article, "The Measurement of Gloss" in the January, 1930, issue of the Journal of the Optical Society of America. "The smoother the surface the greater is the intensity of the specularly reflected light and the greater hence is the luster. It is recognized that if two materials, one white and the other black, have the same surface characteristics, the black one will appear the more lustrous. From this statement it is evident that luster may be defined in two ways; first, according to the sensation of luster (subjective) or secondly, according to the actual surface condition (objective). Subjective luster is defined as the ratio of the specular to the diffuse reflection. Now, the manufacturers of varnish, paper, fabric, etc., are interested primarily in the surface itself, regardless of the nature of underlying color. In other words they are interested in producing materials of definite finish and this problem is attacked by formulating a definition of objective gloss.

"Objective gloss is here defined as the ratio of the intensity of light reflected specularly from the material in question, at a stated angle of incidence, to the intensity of light reflected specularly from a perfectly polished surface of the same material at the same angle of incidence."

The "teacher shortage" of but a few years ago no longer exists in any of our States. On the contrary, many of the States have recently found themselves in the novel predicament of having many well trained teachers unemployed. Many others have been compelled to accept positions for which they had not been especially prepared. Most of the larger cities have thousands of teachers either unemployed or working in some other field and waiting a chance to get a teaching position.

STUDENT EQUIPMENT IN BIOLOGY CLASSES.

By Howard C. Abbott,
Evansville College, Evansville, Ind.

The practice is quite universal in laboratory classes of biology, botany or zoology, for each student to purchase a dissecting set. Such a set in an attractive case usually contains the following instruments: scissors, forceps, 2 needles, celluloid ruler, and a scalpel. Likewise, there is needed a hand lens, slides and cover glasses. The total cost for these may range from two to four dollars depending on the quality of the instruments. There are decided disadvantages to the practice of students in an elementary biology, botany or zoology course furnishing their own equipment.

1. A delay in starting work at the first laboratory period. Even if a list of supplies needed has been given out previously, there are always some students who forget or procrastinate, and come to the laboratory period without equipment.

2. It is not uncommon for students to purchase from other students the instruments used in a previous year. It is often that these second-handed sets are incomplete, i. e. lacking a ruler, needles, or some other essential part. Such a student attempts to work in the laboratory without complete equipment and necessarily is at a disadvantage.

3. The supply is not always sufficient for the demand made by students, hence a delay in some students obtaining the necessary equipment.

4. The cost of equipment has been found by checking up with students to be three to five dollars. While such an expenditure of money is of small consideration to most students, the fact remains that the resale value is small. In most cases the dissecting set is not used again as only about twenty five per cent of the elementary students take any advanced courses.

In order to cope with these unfavorable conditions arising out of years of teaching, the department has purchased a supply of the instruments, lenses, etc. Each student at the first laboratory period makes a deposit of three dollars and receives a set of the necessary equip-

ment and a breakage ticket. The equipment received is as follows: 1 pair forceps with fine curved points, 1 pair scissors, 2 needles, 1 celluloid ruler, 1 gitsnife, 1 scalpel, 1 tripod lens, 1 slide box, 20 glass slides, 1-4 oz. of cover glasses, and a cheese cloth towel. Each article (except slides and cover glasses) is stamped with a number. Thus set 1 will have this number on each article and the number corresponds to the locker drawer. Thus, when a ruler or a tripod lens has been left in the laboratory, it is possible to identify to whom the article belongs. Also this is a guard against the students taking articles belonging to other students to replace a lost article. At the close of the semester, the articles composing the set are checked back by the instructor, and any loss or breakage is taken out of the three dollars deposit. The balance is refunded to the student.

Such a system has advantages, some of which are:

1. Each student has the necessary equipment to work with at the first laboratory period.
2. The equipment is uniform and standard, thus any explanations given by the teacher are more readily understood by the students.
3. The cost to the student for a laboratory course is reduced, and a good grade of dissecting sets may be used over a period of many years.

Another system that has proven effective in laboratory classes in biology should be mentioned. It is necessary to use prepared slides for study of many parts of plants or animals. The initial cost is fifty cents or more, and often these slides are broken by students. It is often difficult to determine who is responsible for the accident and the breakage is a total loss. Each student is given several cards cut the size of a slide (3″ x 1″). The students write their name on the card, and when a prepared slide is issued the card is placed in the slide box in place of the slide. When the slide is returned, the card is given back to the student. Thus when a slide is missing the student at fault is easily determined and the cost of the slide is punched out of a breakage ticket.

For years, classes in chemistry have issued equipment to the students. How efficient would a course in elemen-

tary chemistry be taught if the student was required to furnish test-tubes, beakers, ets.? Just what disposition would the student make of this glassware after completing the course? What effect would such a plan have on the total enrollment in an elementary chemistry class? Yet these objections have been valid for years in biology classes. Such a plan as has been described is applicable to biology classes in high school as well as in college.

Our educational ways have grown up with us to a great extent. What was done by our teachers, we are prone to adopt when we become teachers a few years later. A generation of students in college is only four years. Any new method that has been proven by experimentation to be an improvement will become a custom in a short period of years. The student today may be teacher in later years, and in that capacity will pass on the best methods evolved and in practice by their teachers. Since this method has been in use for a number of years and has given very satisfactory results, it is presented here for the benefit of other teachers.

ELECTRICAL EYE SEPARATES METALS.

Man has been looking at minerals and metals since the first iron, that fell from the heavens as flaming meteors, attracted the attention of cave dwellers. But not until now has he sought to classify metals by simply looking at them.

Early scientists weighed metals to separate those of different qualities. Then electrical and magnetic conductivities were measured. Later solubility, wettability, crumbleability and surface tension were means of classification. And just recently the appearance of minerals and metals to an electrical eye has been used to separate one kind from another, Prof. Roy W. Drier, of the Michigan College of Mining and Technology, has reported to the American Chemical Society.

Prof. Drier's apparatus, though experimental, promises to lead to the saving of valuable minerals and metals of industry now wasted. A successful test was made on the separation of silver and copper ores which occur together on the upper peninsula of Michigan. Colored rock salt was satisfactorily removed from the product of the St. Clair valley leaving the white crystals for commercial use.

The apparatus provides for particles of the material under test to fall upon a moving, black, endless belt. They pass under a constant source of light, a part of which is reflected back to a photo-electric cell. Some particles reflect more light than others and thus set up different currents through the cell, which are amplified to operate a mechanical apparatus that removes the material whose reflection index is above or below a certain value.—*Science Service.*

HOW HELP THE BEGINNER TO STUDY CHEMISTRY?

By FRANCIS C. COULSON,
Crane High School, Chicago.

One of the foremost difficulties, perhaps the chiefest, experienced by the chemistry beginner is how to study the subject. That problem arises at the beginning mainly because of the pupil's inability to observe the purpose of the laboratory, the classroom and home work, and their relationship to each other. In order that the beginner can better be able to relate those three phases of the subject for study, a mimeograph copy "Helpful Suggestions For the Chemistry Beginner," found later in this article, is handed to each pupil shortly after classes are organized. It will be noticed that much of the detail of the methods does not appear in the copy but that is left to the instructor to present directly as the course procedure demands. It might be well to give in some detail some of the methods used which are the basis for the mimeographed copy.

To help the beginner in the laboratory to study, it is well to work with the class a fairly heavy experiment by demonstration at the beginning of laboratory work. By that procedure the instructor can point out the method of attack,—first, attentiveness to the purpose of the experiment and thoughts of it during the performance, then careful observations, followed by interpretation of results, and lastly the stating of a conclusion based on the purpose. The summing up of an experiment for a conclusion seems to bother a pupil most. To inspire study while an experiment is being performed each pupil should be made to present to the instructor at the completion of the experiment all the products of his experimentation, with an explanation of how they were obtained. Briefly, as an example, after completing the experiment "Types of Chemical Changes," let the pupil bring to the instructor the test tube after heating mercuric oxide and be responsible for such questions as, What is and how recognize the substance condensing toward the mouth of the tube? What escaped and how test for it? What type of chemical change? A similar procedure can be resorted to for the part dealing with burning magnesium and the part involving the precipitation reaction. That method involves a lot of work

but dividends are lucrative, for it helps the pupil to become aware of the importance of an experiment throughout its entirety and at the same time become less dependent on his fellows. There have been several opinions expressed relative to writing up experimental results. It does seem that the formal write-up can be dispensed with and the time better directed to other channels in the laboratory.

The classroom is a convenient place for motivating good study habits. Under supervision there, economical methods of studying can be demonstrated for use outside of school. Briefly the pupil might have two notebooks in addition to the laboratory notebook, one only for exercises in the classroom and the other for the pupil's individual use. There are many exercises for the teacher and pupil working together in the classroom, some which can be completed, others merely started and finished out of school. That method of keeping all pupils busy is perhaps preferable to conducting the classroom after the oral question—barrage fashion. As an example, suppose oxygen was prepared and studied in the laboratory. Right then in the classroom in order to *collaborate* the work of the classroom and laboratory an opportunity is offered to begin to construct for the first time formula by using those for metallic and non-metallic oxides and at the same time name them. Presuppose, however, that the symbols and valences of a number of the common elements had been memorized. The pupils can be shown methods for memorizing at a time a few symbols and their valences. It is better to have pupils ask for more than to load them down with a lot of memorizing at the beginning.

For helpful study outside, guide or study sheets are very beneficial whether or not the unit system is used. A study sheet on oxygen can include questions on the occurrence, preparation, properties, combustion, classes of oxides, exercises on formula, and per cent problems. The pupil should be shown how to attack a chapter in the text during its study.

It was not meant to make this article an exhaustive treatise on teaching the pupil to study. Very much more can be mentioned, especially detail about methods to use. A sample of the mimeograph copy given to each pupil follows:

HELPFUL SUGGESTIONS FOR THE CHEMISTRY BEGINNER.

At the very beginning a pupil should not feel that chemistry is a very hard subject to grasp or that its acquisition is practically impossible. That situation is passed on to others unfamiliar, by those who failed because they simply would not apply themselves the first few weeks. Thus, they did not get at the beginning the fundamental principles as the course progressed and became for that reason discouraged and finally gave up. Any pupil who will advance sincere effort toward studying chemistry will do work of such quality that not only the instructor will be pleased but even the pupil will receive much satisfaction. Some may need to give a little more time. A little close attention toward acquiring the fundamentals the first semester will automatically cause the second semester's work to be more pleasurable.

The laboratory, classroom and home work should all be associated together, and not treated as separate elements in the study of chemistry.

I. *LABORATORY.*

The laboratory is the real place to learn chemistry. There each pupil has the opportunity of coming in contact with substances through his own observations and activities in general and thus acquire first-hand experience. Besides improving accuracy and methodical procedure there are for each pupil desirable habits to be secured through manipulation, such things that experimenting should help to acquire in addition to chemical facts.

To receive the most possible from an experiment do not be too hasty to have it finished. The process should be similar to the following:

1. First see what the notes at the beginning of each experiment contain. They serve as a skeleton upon which to build as the experiment proceeds.
2. Fix clearly in mind the nature of, the purpose of, or the object of the experiment. Carry it through.
3. Try to see why any part should follow the preceding part of the experiment.
4. Make all observations carefully. That is a place where helpful habits can be acquired. Plenty of time should be used but none squandered.

An observation is a fact that one obtains chiefly through the senses, i. e. through sight, smell, touch, taste, etc.

5. Do the best possible at arriving at some conclusion based on all you have done. First think of the purpose of the experiment.

Conclusions arrive mainly through mental effort and endeavor to relate observations and experiences to each other.

6. Carefully make all tabulations and experiment write-ups after whatever manner the instructor suggests.

For each experiment done the pupil should be responsible for:

1. Its purpose in his own words.
2. The important observations made.
3. The conclusion to the experiment with the reasons for the conclusion.

Try to take out of the laboratory in the mind what chemical facts were learned while experimenting. Review them before coming again. Dwell awhile longer on the new facts. If any pupil will try hard to do his part in the laboratory and attend closely to classroom work it will be apparent that chemistry is not difficult to grasp.

II. *CLASSROOM.*

The classroom work in chemistry is not of the recitation nature such that the instructor endeavors by the end of the period to ask

each pupil a question or endeavors to use the entire period for oral questioning. The pupil must come to the classroom with the idea that it is the place where instructor and pupils work together to iron out difficulties experienced by the majority of the class by means of the explanations and notebook exercises. The more the pupil is attentive there, the more economical he will be in grasping the fundamentals.

In addition to being an individual workroom the classroom is the place for testing the pupils' achievement. Through tests what particular portion of the material has not been grasped is revealed both to instructor and pupil. The watchword expression has seemed to be "A Test To-day?" but if a pupil carries out his laboratory investigations carefully, is responsive in classroom, and does a little outside, he will never fear a test.

III. *OUTSIDE STUDY.*

A. *Text book assignment.*

1. First read the entire assignment through but not too exhaustively.

2. Go over it a second time and pick out those things thought most important. A little experience will simplify that procedure.

3. If the textbook is not private property then the important things in each topic or paragraph cannot be underlined but can be better retained in mind by outlining in a notebook. Reviewing will then be easier.

4. Notice that the treatment of the material in the discussion of the common elements and compounds is the same. Consider oxygen. Notice first come the occurrence and historical facts, then the laboratory and commercial preparation, next the physical and chemical properties, then uses, and lastly any other forms of the element and its compounds. Try to associate those things together for retaining the facts.

5. Endeavor to blend the laboratory work with that of the classroom and textbook, for, as was mentioned before, they are not separate phases. Review as soon as possible after laboratory and classroom exercises.

B. *Memorizing.*

Aided by the experience of a few years the instructor knows just what should be memorized and when it should be done. Help him in that respect.

1. The symbols of the common elements with their valences must be memorized at the time asked, not later. They will be just a few at a time. The method will be given later.

2. Formulae except in a few cases are not to be memorized. There are thousands of them so they are constructed from symbols and valence. They are not memorized.

3. Equations are never memorized except in a few cases. They are written through knowledge of formulae and properties of substances.

4. The properties of certain elements and compounds are memorized.

IV. *MISCELLANEOUS.*

1. *Attendance.* Irregular attendance is a large factor accounting for pupils' failures in chemistry. A pupil must be present regularly to acquire each new principle as it is presented so that he can link the facts and theories from the beginning. That is much more necessary during the first semester. No provision will be made for "make up" in the laboratory.

2. *Independence.* A pupil cannot learn to retain much chemistry by copying from or depending upon another pupil. One must do individual work. A pupil should receive help from the

instructor at a prearranged period during troublesome times.

3. *Notebooks.* In previous classes it was clearly demonstrated that the best pupils were those who maintained one or two well organized notebooks in addition to the laboratory notebook. Special suggestions, explanations, notes from the board, etc., could be found in them. Notebooks are very helpful for reviews.

SOME LECTURE DEMONSTRATIONS IN LIGHT.

By R. C. COLWELL,

Department of Physics, West Virginia University.

With two large spherical mirros about three feet in diameter such as are used in search lights, it is possible to show several striking experiments in radiation to a large class. First of all the mirrors are set up at opposite ends of the lecture desk about thirty feet apart and a stick of wood is ignited in the focus of one mirror by the heat from an arc lamp in the focus of the other. (Figure 1.) By scattering chalk dust in the path of the light rays,

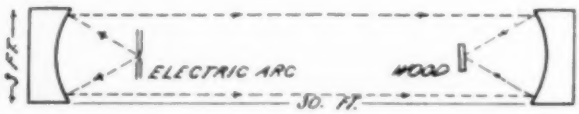

FIG. 1. IGNITING A PIECE OF WOOD AT A DISTANCE OF THIRTY FEET FROM A CARBON ARC.

one may show the direction of the rays for different positions of the electric arc. If one of the mirrors is set upon a rotating stool and a red electric light placed in front of it; then for the proper conditions, the whole class can see the real inverted image and the enlarged virtual image. At the same time the equation $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ is discussed in relation to the images. The physical fact that the angle of incidence is equal to the angle of reflection may be demonstrated by means of the arrangement shown in Figure 2. A Nernst glow lamp is placed behind a suitable collimator and lens so as to give a parallel beam of light. The collimator with the glow lamp is rotatable about a horizontal axis. The beam

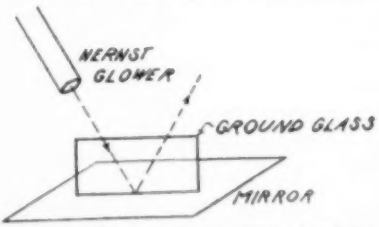

FIG. 2. ROTATION OF THE NERNST GLOWER SO AS TO PROVE THE ANGLE OF INCIDENCE EQUAL TO THE ANGLE OF REFLECTION.

of light is visible across a vertical piece of ground glass. The equality of the two angles is at once apparent. It can also be shown with this apparatus that a change of x° in the angle of incidence changes the direction of the beams by an angle 2x°; this fact is applicable to a rotating mirror.

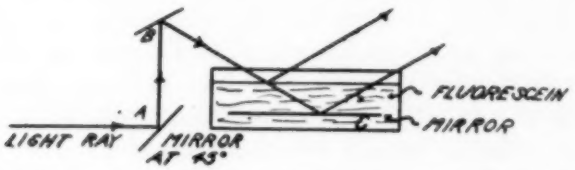

FIG. 3. ARRANGEMENT OF MIRRORS SO AS TO SHOW REFRACTION. ROTATION OF THE MIRROR A WILL GIVE TOTAL INTERNAL REFLECTION.

In Figure 3, a beam of light falls upon mirrors A and B and from them is directed into a tank of water tinged with fluorescen. In the bottom of the tank is a third mirror C. When chalk dust is scattered along the light beam, the class can see the reflected rays from the three mirrors and the refraction of the rays at the surface of the fluid. If now the mirror A is rotated so that the light ray enters the side of the tank and goes in the fluid from below, the phenomenon of total internal reflection may be demonstrated.

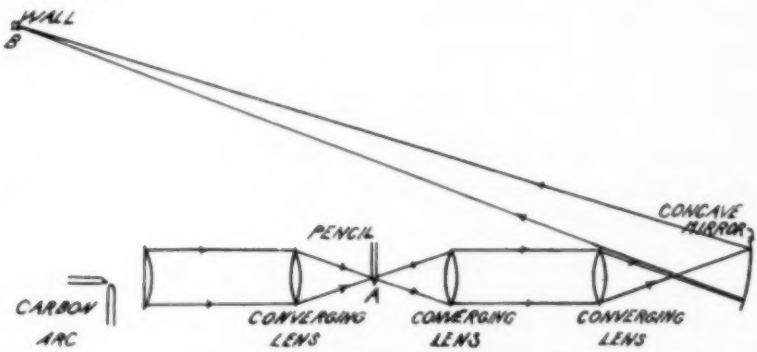

FIG. 4. AN ARRANGEMENT OF LENSES WITH CONCAVE MIRROR TO SHOW THE PROJECTION OF A REAL IMAGE UPON A SCREEN.

Figure 4 shows an arrangement of lenses and mirrors in which the rays are visible and the action of different lenses may be studied. A pencil placed at the point A will have an image at the point B on the wall.

THE ELEMENTS OF PLANE GEOMETRY IN PLANE TRIGONOMETRY.

By Hobson M. Zerbe,

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This study is an attempt to answer the question, "What elements of plane geometry are used in the study of plane trigonometry"? To arrive at an answer to this question an analytical study was made of the development of the various trigonometric laws and formulas and also of the solutions of a number of trigonometric problems. The elements of plane geometry which were used in the development of a law or formula, or in the solution of a problem, were noted.

The elements of plane geometry include fundamental principles, theorems, corollaries and constructions as they are presented in text-books of common usage. The scope of plane trigonometry includes those topics which are generally included in a college course. A number of text-books were examined to determine the scope of a course in plane trigonometry.

The various text-books used in making this study are as follows:

Shibli—Plane and Spherical Trigonometry.
Wentworth and Smith—Plane Trigonometry.
Granville—Plane Trigonometry.
Conant—Plane and Spherical Trigonometry.
Brink—Plane Trigonometry.
Wentworth and Smith—Plane Geometry.
Palmer, Taylor and Farnum—Plane Geometry.
Durell and Arnold—New Plane Geometry.

A list of the topics usually treated in a plane trigonometry course in college and which were analyzed in this study is given below.

I. A—Functions of acute angles.

II. THE RIGHT TRIANGLE.
B—Solution of the right triangle.
C—Solution of the isosceles triangle.
D—Solution of the regular polygon.

III. THE OBLIQUE TRIANGLE.
E—Development of the law of sines.
F—Development of the law of cosines.
G—Development of the law of tangents.
(By geometrical methods.)
H—Development of the formula for finding the radius of an inscribed circle.

I—Development of the formula for finding the radius of a circumscribed circle.
J—Solution of parallelograms.
K—Solution of miscellaneous problems involving the oblique triangle.

IV. TRIGONOMETRIC ANALYSIS.

L—Development of the addition formulas; e. g. sin $(x+y)$.
M—Development of the half-angle formulas; e. g. sin $x/2$.
N—Functions of the angles near 0 or 90 degrees.
O—Complex Numbers.
P—Solution of equations and identities involving inverse functions.

In making an analysis of each of the above topics, the elements of plane geometry which were found to occur were separated into two lists. The first list contained those fundamental principles, theorems and corollaries which were used in the study of trigonometry. The second list contained those constructions which the pupil would be expected to know in drawing the figure used in a given discussion or solution of a problem.

In plane trigonometry very little or no time is devoted to the accurate construction of figures used in developing the various laws and formulas or in the solution of problems. A free-hand drawing is very frequently used in lieu of the carefully constructed and scaled drawing. But it cannot be easily denied that a thorough knowledge of the construction principles of plane geometry enables the student to visualize more clearly the conditions of the discussion or problem, thus making the discussion or problem more easily understood.

Space does not permit the listing of the various elements under each individual topic that was analyzed, hence a general summary of the fundamental principles, theorems, corollaries and constructions is given. The letters following each item in the summary refer to the topic in whose analysis the particular item was found to occur.

FUNDAMENTAL PRINCIPLES, THEOREMS, COROLLARIES.

1—Two triangles are congruent if two sides and the included angle of the one are equal respectively to two sides and the included angle of the other. (O)
2—Two right triangles are congruent if the hypotenuse and the leg of one are equal to the hypotenuse and a leg of the other. (N)
3—Corresponding parts of congruent figures are equal. (N, O)
4—The sum of the angles of a triangle is equal to 180 degrees. (G, K)

5—An exterior angle of a triangle is equal to the sum of its opposite interior angles. (G)
6—If two angles of a triangle are equal, the sides opposite these angles are equal and the triangle is isosceles. (C)
7—The angles opposite the equal sides of an isosceles triangle are equal. (C)
8—An equilateral triangle is also equiangular. (C)
9—The perpendicular from the vertex of an isosceles triangle to the base divides the triangle into two congruent right triangles. (C)
10—If two angles of a triangle are unequal, the greater side lies opposite the greater angle. (K)
11—If two sides of a triangle are unequal, the greater angle lies opposite the greater side. (K)
12—Two lines in the same plane, perpendicular to the same straight line are parallel. (A, K)
13—Two lines are parallel if a transversal to these lines makes a pair of corresponding angles equal. (O)
14—Parallel lines included between parallel lines are equal. (J)
15—If two parallel lines are cut by a transversal, the alternate-interior angles are equal. (B, J)
16—If two parallel lines are cut by a transversal, the corresponding angles are equal. (O)
17—If two parallel lines are cut by a transversal, the interior angles on the same side of the transversal are supplementary. (J)
18—If two sides of a quadrilateral are equal and parallel, the figure is a parallelogram. (O)
19—The opposite sides and the opposite angles of a parallelogram are equal. (J)
20—A diagonal divides a parallelogram into two congruent triangles. (J)
21—The diagonals of a parallelogram bisect each other. (J)
22—The diagonals of a rhombus bisect each other at right angles. (J)
23—The acute angles of a right triangle are complementary. (B, G, H)
24—Each acute angle of a right isosceles triangle is equal to 45 degrees. (B)
25—In a 30-60 degree right triangle, the side opposite the 30 degree angle is equal to one-half the hypotenuse. (B)
26—Radii of the same circle or of equal circles are equal. (D)
27—A diameter perpendicular to a chord, bisects the chord and the arc subtended by it. (D, I, N)
28—A central angle is measured by its intercepted arc. (G, I)
29—An inscribed angle is measured by one-half its intercepted arc. (G, I)
30—An angle inscribed in a semi-circle is a right angle. (G, I)
31—A tangent is perpendicular to the radius drawn to the point of contact. (B, H, K, N)
32—Two tangents drawn to a circle from a common external point are equal and make equal angles with the line joining the point to the center. (H, N)
33—If two adjacent angles have their exterior sides in the same straight line, they are supplementary. (G, K)
34—If two angles have their sides perpendicular, right side to right side and left side to left side, the angles are equal. (L)
35—The central angle of a regular polygon of n sides is equal to $4/n$ right angles. (D)
36—The sum of all the angles of a polygon is equal to $(n-2)2$ right angles. (D)

37—In a regular polygon, each angle is equal to $\frac{(n-2)2}{n}$ right angles. (D)

38—The area of a regular polygon is equal to one-half the product of the perimeter by the apothem. (D)

39—A circle can be circumscribed about a regular polygon. (D)

40—A circle can be inscribed in a regular polygon. (D)

41—Two mutually equiangular triangles are similar. (O)

42—Two right triangles are similar if an acute angle of the one is equal to an acute angle of the other. (A, L)

43—If a straight line intersects two sides of a triangle and is parallel to the third side, a triangle is formed which is similar to the given triangle. (K)

44—In similar triangles, the corresponding sides are proportional. (A, L, O)

45—The bisectors of the angles of a triangle meet in a point which is equidistant from the sides of a triangle. (M)

46—The area of a triangle is equal to one-half the product of the base by the altitude. (B, C, K)

47—The area of a triangle may be expressed in terms of its sides. (K)

48—The square on the hypotenuse of a right triangle is equal to the sum of the squares on the other two sides. (B, F, P)

49—The area of a parallelogram is equal to the product of the base by the altitude. (J)

50—In any obtuse triangle, the square on the side opposite the obtuse angle is equivalent to the sum of the squares on the other two sides increased by twice the product of one of these sides and the projection of the other side upon it. (F)

51—In any triangle, the square on the side opposite an acute angle is equal to the sum of the squares on the other two sides diminished by twice the product of one of those and the projection of the other side upon it. (F)

CONSTRUCTIONS.

1—Required to construct a perpendicular to a given straight line from:
- a—A given point without the line. (A, B, C, E, F, I, K, L, N)
- b—A given point on the line. (G)

2—Required to construct a triangle given:
- a—Two sides and the included angle. (K)
- b—Two angles and the included side. (K)
- c—Two angles and the side opposite one of them. (K)
- d—Two sides and the angle opposite one of them. (K)
- e—Three sides. (K)

3—Required to construct a right triangle, given:
- a—An acute angle and the hypotenuse. (B)
- b—An acute angle and the opposite leg. (B)
- c—An acute angle and the adjacent leg. (B)
- d—The hypotenuse and either leg. (B, P)
- e—The two legs. (B, P)

4—Required to construct a parallelogram, given:
- a—Two sides and the included angle. (J)
- b—Two diagonals and one of the angles included between them. (J)
- c—The diagonal and the two adjuacent sides. (J)
- d—The diagonal, a side and the angle included between the diagonal and the side. (J)

5—Required to construct an isosceles triangle, given the base and one of the equal base angles. (G)

6—Required to inscribe a circle in a given triangle. (H, M)

7—Required to circumscribe a circle about a given triangle. (I)
8—Required to inscribe a circle in a regular polygon. (D)
9—Required to circumscribe a circle about a regular polygon. (D)
10—Required to draw a line, through a given point, parallel to a given straight line. (B, K, L, O)
11—Required to draw, from a given point on a line, a straight line making an angle equal to a given angle. (B)
12—Required to draw a tangent to a circle, from a given point without the circle. (B)
13—Required to draw a circle, given the diameter. (G)
14—Required to draw a tangent to a circle, from a given point on the circle. (N)
15—Required to construct a triangle, similar to a given triangle. (O)
16—Required to lay off a line segment equal in length to a given line segment. (O)
17—Required to bisect a given angle. (H, K, M)

ATTACKS MEDICAL MOVIES AS METHOD OF TEACHING.

American surgeons were warned against the use of moving pictures for teaching medical students by Prof. George Grey Turner of Newcastle-on-Tyne, England, who delivered the John B. Murphy Memorial Oration at the annual meeting of the American College of Surgeons here.

"Clinical work cannot be learned by watching cinema demonstrations," he said. "The cinematograph is a dangerous method if it is offered in place of the more laborious plan where the learner comes into direct contact with the patient." He thought it had a very limited field of usefulness, and was chiefly valuable in post-graduate teaching.

"It is a means of bringing before the eyes of many what can be observed closely by only a few, but therein lies the danger," he said. He urged the medical profession of America, and particularly the College of Surgeons, to take a stand against attempts to arrive at medical education by easy routes, of which moving pictures are one. —*Science Service.*

HALF A TON OF STONE WEAPONS IS ARCHAEOLOGICAL HARVEST.

Half a ton of stone axes, arrow points and other weapons and tools once used by Indians who lived in Colorado have been gathered by an archaeological expedition from the University of Denver, led by Prof. E. B. Renaud.

The expedition, which has returned to the University, covered 10,000 miles in making the first archaeological survey of eastern Colorado. More than 250 Indian sites were found. The survey fits into the Smithsonian Institution's program of locating as many of the old Indian camping grounds, villages, and shelters as can be identified today.

Indians of different parts of the region explored used different materials for their stone implements, the survey found. Petrified wood from the Black Forest was found "just as good" as ordinary stone in the central highlands. Quartzite of varied colors was most used in some other sections. Flint was common in the northern part, and a black slaty material was much employed in the southwest.—*Science Service.*

THE COST OF THE HIGH SCHOOL SCIENCE DEPARTMENT.

By A. C. MONAHAN,

Formerly U. S. Bureau of Education.

The science teacher who desires to build up his department with increased enrollment and better laboratories, has got to take steps to show his superiors—superintendent, principal and school board members, that the expenditures for the department are justified. This will be indicated to them by the number of pupils electing the subject and by the interest shown in the science department by parents and men and women of the community served by the school. A few words of commendation of the science department on the part of a leading citizen to a member of the school board will have great weight in increasing the prestige of the work in his eyes.

One important preliminary step is to show that the cost of the department of science is not excessive, that the annual per capita cost including supplies, while usually greater than that for academic subjects, is usually less than for industrial arts, home economics, and certain other subjects. It is usually less than the cost of academic subjects in which the class sections are small as is often the case with Latin and certain foreign languages. When the first investment in permanent space and equipment is considered it is often less than for typewriting, art, music, and physical education, as well as for the industrial arts and home economics.

Every science teacher should make an analysis of the cost of the various departments in his school. He would then have data to present to his superior officers. It is not a difficult task. A school can be easily divided into about 10 departments for this purpose: English and Literature, Mathematics, History and Civics, Ancient and Modern Languages, Commercial, Home Economics, Industrial Arts, Music, Physical Training, and Science.

Three per capita comparisons should be made: on salaries only, on salaries and annual instructional supplies, and on these two items plus permanent investment in space and equipment. The costs must be reduced to a comparable basis. Many bases have been used in cost studies but perhaps the most common is that of the cost per pupil per year,

one school period per day. The teacher's total salary for the school year is divided by the total number of periods for the school day. The result is divided by the average daily attendance in each of his classes. This gives the cost per pupil per year on a basis of five periods of recitation in each subject a week. Certain classes may have more or less than five periods per week; they have to be reduced to the five periods basis for comparison.

In certain high schools where cost studies have been made, only the number of periods that the teacher is actually engaged in teaching is used. This is hardly fair in the average high school, for the teacher is engaged in supervising a study hall or giving students individual attention, or some other form of work, during the periods when he has no recitation. It would be fair in any school where the teachers have the periods not scheduled for classwork, free for rest or study or preparation for coming classes, or for any other form of "outside work."

A study on the basis of salaries only will show very little difference in the cost from that of any other department. The two figures influencing the variation are the individual salaries paid the instructor and the size of the class. Science teachers are paid on the whole no more or no less than academic teachers, and their classes are about the same size. One would expect a larger enrollment in English classes as in almost all schools all pupils are required to take four years of English work, and the cost per pupil per year would be low. This is the fact in most of the studies made. Subjects in which a large group can be handled by a single instructor have the lowest cost per pupil per year—group music, physical training, and so forth, being among them.

The results of some of the studies made on this basis will be of interest to the science teacher, and helpful to him in

COST OF INSTRUCTION PER PUPIL IN HOLYOKE (MASS.) SENIOR HIGH SCHOOL.

Special English	$30.70	Music	$22.80
German	30.25	Household Arts	21.40
Industrial Arts	26.25	French	21.15
Arts	26.15	History	18.30
Latin	23.85	English	15.70
Mathematics	23.65	Commercial	15.60
Science	22.85	Physical Training	12.85

the problem before him of developing his department. In Holyoke, Mass., a recent survey gives these results. They are from the senior high school in which 1027 pupils were enrolled, enough so that full classes in each group could be obtained.

The situation in small high schools in the same State may be summarized from a study made by J. T. Hood, Principal of the Wilmington High School, Wilmington, Mass. His figures have to do with 56 high schools with 200 or less enrolled. The results are published in *Nations Schools*, for September, October and November, 1929.

His figures are given as "Pupil-hour" costs. Multiplying them by 180 (the number of days in the school year) gives the cost per pupil per year as follows:

Latin	$28.08	French	$17.64
Mathematics	23.22	English	12.78
Science	19.44	History	9.90
Commercial	18.54	Miscellaneous	27.90

In the table above, "miscellaneous" includes art, industrial arts, music, physical training, home economics, etc. Mr. Hood explains the low cost of History by citing that it is customary to combine, in the Massachusetts schools, in one class in History, pupils from different class grades.

One would expect in the smaller high schools that the cost of instruction would be less in the first year than in the last, because of the decrease in enrollment. This is true as shown by Mr. Hood. Taking the schools in his study in which the enrollment was between 150 and 200, the cost in the various years was as follows:

	Freshman	Sophomore	Junior	Senior
Latin	$19.36	$36.18	$36.00	$40.86
Mathematics	15.12	31.32	34.28	46.80
Science	5.90	12.60	34.28	34.20
Commercial	9.72	20.16	26.28	34.92
French		11.16	20.16	36.36
English	5.90	13.32	13.14	12.42
History	8.46	11.34	10.62	10.80
Miscellaneous	27.90	27.90	45.54	45.54

The Cleveland school survey of 1928-1929 gives interesting figures for a larger number of individual subjects than the two Massachusetts studies whose figures have been quoted.

Art	$19.17
English	15.75
English (special)	20.40
Foreign languages:	
French	21.84
German	22.05
Latin	20.36
Spanish	18.56
Home Economics	16.82
Mathematics	16.37
Mathematics Advanced	21.82
Music	8.29
Music Special	20.50
Physical Training	5.21
Typing	12.39
History	15.09
Other social sciences	14.07
Science:	
General Science	$16.37
Biology	15.03
Chemistry	17.68
Physics	18.97
Vocational:	
Printing	19.97
Foundry	16.83
Commercial	16.36
Electricity	15.22
Machine Shop	14.83
Shorthand	14.68
Drawing	14.65
Pattern making and woodwork	14.36
Automobile	13.39

A. W. Evans, of the Texas Technological Institute at Lubbock, made a study of high school costs in Texas in 1924, at which date he was chief supervisor of secondary education in the Texas State Department of Education. The report is printed in the *School Review* of February, 1926. His data is from 390 Senior and 12 Junior High Schools. They include 12 schools with over 1000 pupils, 17 with between 999 and 500 pupils, 16 with 499 to 350 pupils, 31 with from 350 to 200 pupils, 126 with from 200 to 100 pupils, 139 with between 99 and 50, the remaining forty-nine having between 49 and 9 students. Thus his table represents costs in schools of all sizes.

He designates the groups given above, beginning with the largest group as Group 1, making Groups I to VII, respectively. With all high school subjects under eleven headings, and arranged in order of their cost from the most costly to the least costly, Science is the fourth subject in Group 1; third in Groups II, III, and IV; sixth in Groups V and VII, and seventh in Group VI. Manual Training and Home Economics, included in all seven groups, both rank ahead of Science as more costly. Vocational agriculture and general agriculture are also ahead of Science in the three groups where they are included. In the seven groups, French is ahead of science once, Latin, twice; and Commercial three times, in respect to cost of instruction.

Evans gives in his article a digest of twelve separate cost studies in different parts of the United States with the subjects again arranged from the most costly to the least. There are between nine and twelve subject headings in

these studies. Science is the second most costly subject in two instances, the fourth in four, the fifth in one; the sixth in two, and the eighth in three.

From all of the above studies it is evident that throughout the United States instruction in Science, when the teacher's salary and the size of the class only are considered, does not cost any more than the general run of academic subjects, and as a rule, less than such special subjects as home economics, vocational and industrial arts, etc.

The inclusion of the instructional supplies with the various subjects will increase the cost of science instruction over the academic textbook subjects but on the whole, not as much as the cost of home economics, industrial arts, vocational work, and often arts, drawing and music. In the report of the Board of Education of Pueblo, Colorado (District No. 1) for 1929, is a study of the cost in instruction in the high school for that year. The cost includes salaries, textbooks, and instructional supplies. It is on the basis of cost per pupil five periods a week, for the year. The school has 770 students.

Auto shop	$102.46	History	$22.46
Home Economics	47.60	Commercial	21.98
Art and art metal	42.13	Vocal music	21.73
Woodworking, drafting	39.98	Mathematics	21.12
Painting	39.34	English	20.07
Biology	29.45	Band	19.87
Science	28.83	Gymnasium	18.82
Latin	23.11	Spanish and French	18.42

In a bulletin of the U. S. Bureau of Education, published in 1927, entitled *Laboratory Layouts for the High School Sciences*, are approximate costs of equipment and annual replacement, for Chemistry, Physics, Biology and General Science. They were obtained from a considerable group of schools and represent what may be regarded as average costs from schools of 200 to 400 pupils with approximately one-half enrolled in science classes. The lists on which these costs are based include slightly more than is required by the various state departments of education for approved high schools, and also more than is required by the principal national accrediting agencies. They include considerable less than is found in the larger high schools.

In the bulletin the figures are reduced to the cost for a class of twenty-four pupils. The amount listed as for "in-

dividual students" is for a group that size. By referring to the table it will be noted that the amount listed for Chemistry is $325, of which $140 is for "student desk apparatus," and $185 for "individual pupil" use, such as test tubes, beakers, etc. If a school had forty-eight pupils in two sections the student desk apparatus would not need to be duplicated, but the individual student's apparatus would.

In Physics, the same "individual student" apparatus would be used by two sections, so the cost for the item would be little more for forty-eight students in two sections than for twenty-four in one. The same applies to Biology and General Science.

APPROXIMATE COST OF APPARATUS, EQUIPMENT AND SUPPLIES FOR HIGH-SCHOOL LABORATORIES.

	Chemistry	Physics	Biology	Gen. Science
Individual student (24)	$ 325	$1,150	$300	$185
Demonstration (necessary)	225	260	150	115
Demonstration (desirable)	300	650	200	15
Chemicals, supplies	100	.....	60	35
Tools, stock supplies	50	180	.....	.....
Models and charts	.....	.....	200	.....
Total	$ 700	$1,590	$600	$300
	1,000	2,240	–910	–350
Annual Replacement	$240–360	$200–360	$50–200	$50–100

In the above table from the Bureau of Education bulletin, "individual student" apparatus in Physics and in General Science, includes only enough for students working in pairs, or alternating in the use of apparatus. With some of the more expensive pieces, only one for every four pupils is included. "Necessary" demonstration apparatus means what is required for accredited courses, "desirable" is additional which every school should have to give a satisfactory course.

The bulletin gives for annual replacement, not only the amount needed for useable supplies, but also enough to allow for the repair of permanent pieces of apparatus, and to purchase some new pieces to take the place of ones made obsolete by the development of newer and better models. The cost in chemistry per pupil a year for replacement is from $10 to $15. In actual practice in many schools part of this is met by the pupils, as paying for broken apparatus and equipment is commonly required. For Physics, the cost is $8 to $15 per year; for Biology, $4 to $16; and for General Science, $4 to $8.

If a school had two sections of 24 pupils in any or all of these four sciences, the annual replacement cost per pupil per year would be somewhat less than the amounts given above. The first costs would be considerable less.

Other studies might be referred to, but space will not permit. Figures will be given later on the value of the apparatus in 278 high schools in South Dakota, quoting from a study by Mr. J. H. Jensen, of the State Teachers College, Aberdeen. He shows that the average total value of apparatus and supplies in these schools is $420 for Physics, $332 for Chemistry, $197 for Biology, and $122 for General Science, making the annual replacement costs much lower than the figures given above.

The annual cost of supplies for academic work is of course very small. If free text books are furnished their per capita cost is about the same in all departments. Reference books for the various departments require about an equal outlay. History, physiology, and certain other subjects require a number of charts and models, and lantern slides if a stereopticon is used. The annual cost is but slight.

When we consider the annual costs for supplies and equipment for industrial arts, home economics, drawing and typewriting, we find a different situation. Few studies seem to be available, but from those we have, some conclusions may be drawn.

	Value of Equipment Class, 10-15 Pupils	Annual Cost of Supplies per Pupil
Machine Shop	$5,000 to $15,000	$10 to $15
Carpentry	1,000 to 3,000	10 to 15
Electric Wiring	1,000 to 3,000	10 to 15
Printing	1,000 to 10,000	5 to 10
Painting	4,000 to 1,500	5 to 10
Sheet Metal	750 to 2,000	5 to 15
Plumbing	1,000 to 2,500	10 to 15
Pattern making	800 to 2,000	5 to 10

A publication of the Federal Board of Vocational Education, issued in 1918 entitled "Buildings and Equipment for Schools and Classes in Trade and Industrial Subjects," gives approximate costs for equipment, and for annual expenditures for replacements for certain courses in trade schools. It must be remembered that these figures were published in 1918 when prewar prices prevailed. The cost

of equipment for vocational industrial arts courses in regular high schools should be equal to these.

For Home Economics few figures on costs are available. In a bulletin issued in August 1930 by the Illinois State Department of Education entitled "Home Economics Education and Organization and Administration in Illinois" is a statement of the money which local communities must provide for Home Economics Classes:

> "A minimum of one dollar per month for each pupil enrolled in foods classes, twenty-five cents per month for each pupil enrolled in clothing classes and twenty cents per month for each pupil enrolled in the home or home problems classes is recommended for perishable or temporary supplies."

The Illinois school year is approximately nine school months. Therefore the amount per year required by the above is $9 per student in foods, $2.25 in clothing and $1.80 in home or home problems classes. Note that these are not the total annual costs per pupil of these departments. They are for "perishable or temporary supplies" only.

The Delaware State Department of Education secured reports from various high schools of the State on the cost of two courses in "clothing." In ten schools which reported on "Home Economics I" the average was $9.54 per pupil. In eight schools reporting on an advanced course the average was $14.16 per pupil. Articles of clothing made had, of course a money value.

The State Teachers College at Kearney, Nebraska, found in a study that the cost of supplies for students in "food classes was ten cents per pupil per lesson, and for clothing students, two and a half cents." On the annual basis these would mean $18.00 and $2.50 respectively for foods and clothing pupils for supplies.

A study in South Dakota made by Miss Clara Flemingham found the average cost of "food classes as $2.44, including supplies, fuel and laundry work." In Missouri the State Department of Education found the average cost in 39 high schools for food classes to be $4.16. These figures from both of these states are from schools which include many with a small enrollment. They should be used in comparison with Jensen's figures for cost of science equipment in the high schools of South Dakota, rather than with the study quoted from the U. S. Bureau of Education.

THIS IS AN INTERESTING WORLD IN WHICH WE LIVE; CULTIVATING ATTITUDES IN BIOLOGY.

By Orra Olive Dunham,
Collinwood High School, Cleveland, Ohio.

"The changes wrought by science are threefold. They relate to the material conditions of living, to social institutions and practices, and to what we sometimes call outlook on life or attitude toward the world." It is this changed outlook on life or attitude toward the world that I wish to discuss. Not as it has come to the adult man, but as in biology we present it to our boys and girls.

All problems track back to what makes a good life. What is the best way of getting the most out of life? This means the teaching of the subject, biology, in terms of everyday living. We wish to teach what the student can use now, not what he needed ten years ago. We aim to develop in the individual student the mental, physical, social, and moral abilities that will enable him to live a healthy, happy life; to adapt himself to his environment in the home, the school, his neighborhood, his city, life.

One author divides biology into three parts. (1) Getting Acquainted With Life, (2) Biology and Health, (3) Biology and Wealth.

In "Getting Acquainted With Life" or in beginning the study of biology a whole new world is opened to the pupil, a world of vast importance to him for it is the world in which he lives. He studies the parts of a flower, sees the growth of the pollen grain, the development of the seed and the cycle completed by the growth of the seed into another plant. In studying insects he is trained to interpret environment and later to build up an intelligent interest in his own environment.

The use of the microscope opens another world with plants and animals as well adapted to their environment as those with which he has been familiar. Curiosity is aroused and the student is stimulated to gain new knowledge by his own efforts.

Animals seemingly differ so much from plants that it is a surprise to the student to find that both are built of cells of the same material, protoplasm, that both grow,

move, and are irritable or respond to their environment. He sees the cells of the onion skin, and cells from the lining of his own mouth and learns to visualize all plants and animals as built of cells. This is a wonderful world in which we live.

Long before beginning the study of biology the student had learned to classify some things—the stamps in his collection, the books in the library. He now begins to sort the plants and animals into the phyla or classes. He realizes more clearly the difference between the little one-celled plant bacteria or spirogyra that reproduces its kind merely by splitting in two, and the angiosperm with its carefully enclosed and protected seeds. In almost every animal phylum he finds an animal that he already knows so that selecting others, that, because of their structure, fit in the same group is not so difficult and the development from amoeba to man is a never ending source of wonder.

If man (the pupil) is to fit intelligently into his environment the exploration must go on. He learns that plants and animals are not only composed of the same substance, protoplasm, but that the same twelve or more elements that build up the plants are exactly the same elements that compose his own body. That man is literally "made of earth" because every particle in his body, like every particle in every other living body comes indirectly out of the soil, out of the water, out of the air—the material world in which we find ourselves.

When asked which is more independent in securing his food, plants or animals—man—the majority of a class will answer positively man. Many pupils are greatly surprised when they learn that they are wholly dependent upon the plant. That it is the plant, through the magic of the chlorophyl and the sunshine, that must take the carbon, hydrogen, oxygen and nitrogen and build them into nutrients to nourish man and the other animals. In the attempt to solve the mystery of how it is done he boils the leaf in alcohol to remove the chlorohyl. Using the microscope, he finds the wonderful openings, stomates—and the guard cells on the under surface of the leaf. He studies stems and roots to see

how food is carried up and down. He puts celery stems in liquid colored with eosin or red ink to see how soon the liquid will travel to the leaves. He sets up osmosis experiments and find that liquids really can pass through plant membranes and animal membranes. This is an interesting world in which we live.

In his study of "Biology and Health" he learns that his own body, by wonderful chemical processes, makes over the bread, butter, meat, milk, potatoes, lettuce, fruit, or the carbohydrates, proteins, fats and vitamins into flesh and blood, bone and muscle. He learns that energy is stored up when the food is oxidized in the bodies of animals. He sets up laboratory experiments to find what nutrients are in foods—he studies to know how much of each is necessary. But how does the food get from his stomach to the tip of his finger? He recalls the osmosis experiment when he proved that liquid can pass through animal membrane. He learns that his own body can take a potato, change the starch in it to sugar, carry the same sugar to the cells, oxidize it and give him energy enough to win at the track meet. *This is a wonderful world in which we live.*

Most pupils know that in the furnace at home oxidation takes place only when fuel and oxygen are taken into the furnace and waste products carried away. He is usually interested in discovering what ingenious system nature has devised to carry supplies to every cell of the body and to carry wastes away. The solution of the problem involves a study of respiration and circulation. Again using the microscope he sees the blood circulate in the tail of a fish and he pricks the end of his finger with a sterilized needle, mounts a drop of blood upon a slide and sees the red and white corpuscles of his own blood.

Psychology as a word is not altogether unknown to tenth grade pupils but their knowledge of its meaning is very vague. In biology we cannot say that we study psychology, yet the great aim of a study of the nervous system, is to create in the pupil a desire and a purpose to develop a normal mental life. To develop such wholesome mental habits and attitudes as happiness, hopeful-

ness, faith in the goodness of life, courage, habits of success, loyalty to ideals, confidence in oneself, self-control. Here he learns that it is through the five (or 25) senses that he becomes acquainted with this wonderful world. He studies some of the receptors and adjustors that make us aware of our environment and able to adjust ourselves to it. He learns to apply and use the facts developed and to realize that the success of any plant, of any animal, of any individual depends upon its ability to adapt itself to its environment. "Now the healthful mental state can be developed just as surely as big muscles can. The process is neither so simple nor so easy, but it is not too much to say that most persons can so direct their thought and so order their lives as to attain gradually a higher level of control and than either heredity or training would have promised. Mental training means a training in control, in removal of unwholesome states, and in substitution constantly of wholesome plans, purposes and satisfying interest."*

The microscope is again used in the study of Microscopic Plants—Bacteria. Most students know that bacteria cause disease. They do not know, however, that under favorable conditions a bacterium will reproduce every twenty minutes. Many of a mathematical turn of mind spend hours in finding how many bacteria will grow from one bacterium in 24 hours. Agar plates are prepared and are exposed in the laboratory, lunch room, library, halls, and wherever students see fit. Some are usually taken home and exposed on the bus or street car. When kept at a proper temperature the bacterium or yeast or mold that has fallen on the plate soon grows to a colony and can then be studied or perhaps removed to a test tube as a pure culture. If bacteria are everywhere, then cuts and wounds should be sterilized and other necessary precautions taken to keep germs from entering the body. They also learn that there is a scientific reason why in Pasadena, Cal., only 37 out of 1000 children die under one year while in Cleveland there are 65 out of 1000 and in El Paso, Texas, 169. They know how and why toxin-anti-toxin is used—the Widal

*Williams, J. F., Personal Hygiene Applied, W. H. Saunders Co., Philadelphia.

test, the Schick test, the Dick test and why vaccination is necessary—and that if their own bodily resistance is kept as it should be the phagocytes and antibodies are victors over most of the germs of disease. They learn the debt humanity owes to Pasteur, Koch, Leeuwenhoek, Lister, and other great research workers.

Under "Biology and Wealth" is a study of conservation and of the methods of improving plants and animals. Heredity may not awaken great interest but the topic, "Why do children look like their parents" will arouse curiosity. A class experiment showing variation in height, weight, and length of middle finger will establish belief in the principle of variation. The very fact that each individual in the class resembles his ancestors will establish the principle of heredity. A review of cell structure with a careful study of chromosomes is taken to give the pupils a physiological basis for a belief in the principles of heredity and variation. Heredity charts of the Jukes and Killikak families are studied, also the Edwards family. One boy in discussing the question, "Why study biology," said, "I may be about to marry. I will look up my fiancee's family to see if it is O.K."

And last, but not least, comes Biology for Leisure Time. The machine has given man leisure undreamed of a century ago. The building trades already have a five day week. A new responsibility, a training for wise use of leasure time is now thrust upon the schools. This is the answer of Biology. Under the heading, "Biology for Leisure Time," comes a study of birds, trees, spring wild flowers, gardening and fall wild flowers. The study of birds is taken up about March first and a bird calendar is kept. We study birds chiefly to be able to identify them. The beauty of song and plumage is emphasized and economic importance is stressed. We obtain mounted specimens from the Educational Museum and Museum of Natural History. Friday a boy told me that a wren house, which they put up at home had been unoccupied four years but this spring some tenants moved in. A few days are devoted to a study of spring wild flowers. Some years ago we tried, rather successfully to have each pupil collect and mount an herbarium of 25 speci-

mens. Now one of our chief objects is to prevent them from picking the plants. We like to have just one or two specimens of a kind, identify from books, then locate them when making field trips. On a recent Monday morning seventeen varieties were brought in.

Gardening is also studied in the spring. Most boys and girls delight in seeing things grow. Various magazines such as Your Garden, The House Beautiful, and House and Garden are used. Seed companies will supply flower catalogs. We plant seeds, draw to scale plans for planting flower gardens, borders, porch boxes and talk learnedly of fertilizers, insecticides, annuals, biennials and perennials.

Trees are studied in the fall when the leaves are on as that is the easiest method of identification. Many varieties are found within a block or two of the school Field trips are made and some pupils identify from fifty to a hundred trees.

A day or two is given to fall wild flowers and weeds. A collection of twenty-five fall flowers is easily made. They, unlike the spring flowers, may usually be taken in any quantity desired.

Through all the work of the year runs the thread of the scientific method. A scientist does not believe things till he has good proofs for them. Whenever possible proofs are obtained by direct observation. Here the student must use his eyes, ears, nose, and sense of taste and touch and repeat the observation many times. If he *must* take a statement on authority the authority must be good. He has learned to ask "Why?", that nothing happens by haphazard chance but that every effect must have a cause.

One boy said, "The study of biology was such a revelation of facts to me that I am now ready to listen to anything in the way of new ideas. It has made me realize the significance and beauty of all things."

THIS IS AN INTERESTING WORLD IN WHICH WE LIVE.

ARTICULATION OF SCIENCE TEACHING IN GRADES ONE TO FOURTEEN.

By W. W. Carpenter, *Professor of Education;* Stephen Lamar, *and* G. L. Waterhouse, *Graduate Students, University of Missouri*

According to the last report of the Secretary of the American Association of Junior Colleges there are now well over one hundred and fifty public junior colleges in the United States.[1] These junior colleges offer many advantages to the young people of the nation, but they also offer many problems to those in charge of the school systems of which they are a part.

The junior college is often merely "built on" the rest of the system and conducted as if it were something entirely separate and apart. There seems to be a feeling in some systems that the "college" teachers are doing quite a different kind of work than the teachers of the elementary school, the junior high or the senior high in the same system.

Certain school officials who were consulted relative to whether their junior college teachers rendered assistance to the teachers of the same subjects in the grades below, were very frank in stating that the idea was impossible. They felt that the training of the junior college teacher was quite unlike the training of the elementary and high school teacher, and cooperation was not to be expected. Other officials were of the opinion that their junior college teachers were exceptionally well prepared to offer advice and guidance. These administrators pointed out that the junior college teacher is often much better paid than the other teachers and as their work in the junior college must be limited to the one field, it was logical to assign them either instruction in another unit or the job of assisting and guiding those who did the instruction.

In an attempt to discover the extent of this type of cooperation, a letter was sent to the 124 public junior colleges listed in the 1928 Year Book of Junior Colleges.[2] In order to narrow the problem to one that could be completed in the time available, the study was limited to the field of

[1]Campbell, Doak. Directory of Junior College, 1930.
[2]This study was started in 1928.

science. Thirty-nine schools returned the questionnaries. While this number represents relatively only a small per cent of the total number of public junior colleges, yet the answers received are very significant.

To begin with, one-third of these schools indicate that they offer no laboratory science. This bit of information is cause for grave concern, but is not the subject of this paper. Another one-third of the group offer science, but make no attempt to articulate the science teaching in the junior college with the science teaching in the various units. The very significant fact is that one-third of these schools do have a plan for one or more of their teachers to teach, to supervise, or to assist in some way, the science in two or more of the units of the system.

These thirteen systems have a total of 26 people immediately concerned with science teaching. Of this number all teach in the junior college except four; these four direct or supervise the junior college science work, but do not teach junior college subjects.

The junior college subjects taught by the twenty-two teachers who do teach in the junior college are as follows:

Subject	*Number teaching*
Chemistry	9
Biology	7
Physics	4
Geology	1
Bacteriology	1

Sixteen of this same group of teachers teach the following subjects in the senior high school:

Subject	*Number teaching*
Physics	5
Chemistry	4
Biology	4
Botany	2
General Science	1

Four of this same group of teachers teach general science in the junior high school. None of the group teach nature study or elementary science.

Fifteen of the same group of teachers have some responsibility for the direction and supervision of science in some one unit or more in the system. There is great variation in the grades assigned, as shown by the following:

Grades over which responsible	*Number*
13-14	4
8-14	3
7-14	3
11-12	2
6-12	2
7-9	1
1-14	0

It is interesting to note that 10 of these combinations include junior college science in a 6-3-3-2 system, that 10 include the upper 2 years of the senior high school, 9 include grades 8 and 9, but none include all the grades from 1-14.

The complete list of all the reported activities of these twenty-six science teachers is given in the following Table.

TABLE I—NUMBER OF SCIENCE TEACHERS PERFORMING CERTAIN ACTIVITIES.

	Activities	*Number*
1.	Teach in junior college	22
2.	Inspect incoming material	22
3.	Keep inventory	20
4.	Check incoming material	20
5.	Keep officials informed of progress and needs	19
6.	Test the results of teaching	18
7.	Articulate with other levels of instruction	17
8.	Aid in selecting text-books	17
9.	Receipt for incoming material	17
10.	Teach a class in senior high school	16
11.	Adjust courses to community needs	16
12.	Adjust courses to individual differences	16
13.	Adjust courses to future needs of students	15
14.	Be responsible for direction or supervision	15
15.	Plan additional space for Science	15
16.	Develop methods of distribution of supplies and equipment	14
17.	Prepare budget	14
18.	Aid in diagnosing student difficulties	14
19.	Aid in selecting subject matter and methods	13
20.	Aid in preparing demonstrations	13
21.	Give demonstration of good teaching	13
22.	Aid in diagnosing teacher's difficulties	12
23.	Observe other teachers	11
24.	Confer with teacher following the observation	11
25.	Teach a class in junior high school	4
26.	Be responsible for subjects in the grades	3

This list reveals that these teachers are rendering very valuable service in their systems in addition to their own class room instruction. It is also evident that their assistance is not limited to the administrative details of preparing a budget, keeping an inventory, developing methods of distribution of their supplies and equipment, but that they are also performing supervisory functions such as

aiding in the selection of text books, testing the results of teaching, and aiding in preparing demonstrations for the class.

Science in the junior college is not so different from science in the other units of a public school system. The junior college teacher is better prepared in subject matter and usually has had more experience than the other teachers of the same subject. Allocating part of the time of such a teacher to the instruction or to the supervision of the same science in the units below offers a way for the school system with a small junior college to more effectively use their junior college teachers.

Not only will there be an improvement in the teaching in the lower units, but the junior college teacher will be in a better position to interpret the needs of his junior college pupils for he will be intimately acquainted with their early science training.

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.

No. XIV. The Place of Agriculture in General Science.

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

Agriculture is in itself a *very general* science. Physics excludes biology. Many good biology teachers know little of physics. Chemistry is restricted to a limited field of knowledge. Astronomy, physiology, hygiene, in fact almost any science may be levied upon to furnish material to be used, with suitable adjustments, in the general science course. But agriculture, doubtless the first of all sciences in point of historic development, is likewise the most inclusive one.

Every general science teacher and textbook makes use of some material which might appropriately be included in a textbook on agriculture. Any sort of plant study could trace its lineage back to the science of agriculture. Much of the animal study, insect study, study of bacteria, and of many of the principles of physics, as capillarity, refrigeration, electricity—all have their application on the farm and will be found included in books on agriculture.

Moreover, many of the principles of agriculture are applicable to the life of a city dweller, as well as to that of a farm boy or girl. If one has even so much as a grass plot and a flower garden he should be informed on such topics as methods of planting, cultivation, and fertilization.

Then, too, perhaps we owe to the city child information that will help fit him for a transfer to the country some time as much as we owe to the country child knowledge that will help make a possible future transfer to city life more possible.

One of the topics having a strong agricultural bent which is very suitable for discussion in any general science class in city or country is the use and behavior of water. In the West, where water is scarce, the most important lesson for the farmer or gardener to learn in connection with the use of water is that cultivation conserves it. The author remembers hearing in his childhood two men discuss the question as to whether a hard packed roadway or the cultivated surface of a field would best hold in the water below. This is a question of both practical and theoretical interest for the general science class.

An experiment well calculated to determine the moisture holding effect of different surface conditions is the following: Fill two tin cans with moist garden soil. Set them on opposite ends of a balance, and make their weight exactly equal. Then pack the surface of one and cultivate for an inch down that of the other. Set them in the sun and wind to dry, and notice that the packed one rises in the balance, showing more rapid evaporation.

The following is a striking demonstration of the above principle and more quickly done. In a shallow dish set a cube of loaf sugar, and upon it pile as high as possible some powdered sugar (or granulated sugar pulverized with a table knife). Pour a little water into the dish and notice it run instantly to the top of the loaf sugar, and there stop. The powdered sugar remains dry.

In the loaf sugar the close contact of the particles makes the action of capillarity rapid; but the loose powdered sugar, corresponding to a cultivated surface in the

garden, prevents the action of capillarity. Its pores are too large and the surface of actual contact between particles is very small. It follows that if water cannot come clear to the top of cultivated soil the sun and wind do not get a chance to carry it away by evaporation.

Transpiration of moisture from the leaves of plants is another topic of very general scientific interest as well as one of the matters about which farmers and gardeners often have to take account, especially at times of transplanting.

Easy and conclusive demonstrations of the fact of transpiration can be made. A thick glass jar or pitcher inverted over growing plants soon becomes damp within. Drops of water may form and trickle down the sides. Action is more rapid in the sunshine. Such an experiment helps make credible the statement that a large sunflower plant will lose a quart of water a day.

A practical inference from the above experiment is that weeds cause great losses of water that should be conserved for the crop.

Osmosis is another phenomenon in connection with the plants' water supply that deserves a place in the general science class. There are a number of simple demonstrations suitable for class room use.

"Goldbeater's skin," sold by school supply houses, or in fact, any semi permeable membrane, such as a piece of parchment or an animal bladder from the slaughter house will give good effects in osmosis. The membrane is tied tightly like a drumhead over the mouth of a "thistle tube," which has first been filled with a sugar or molasses solution. This set in water begins working immediately and forces water up the tube.

An egg serves as an osmostic pressure cell if some of the shell from the large end is removed without breaking the membrane within. A glass tube run through a hole in the small end of the egg and sealed in by dropping wax from a burning candle offers a passage way through which the entering water, in which the egg is immersed, can force the contents of the shell to rise.

Wilting sliced cucumbers by soaking them in salt water is an example of osmosis. Here the more concentrated of

the two solutions is the salty water and therefore the weaker sap passes out through the cell walls leaving the cells partly collapsed. Alkali in the ground owes a part of its deleterious effect upon plant life to this process of reverse osmosis.

An agricultural topic that should find its way into the general science curriculum is man's control of insect pests. This, like forest protection, public health, etc., is a matter of such general interest and importance that it is well to have very general intelligence on the subject so that people will at least give support to public efforts made to prevent spread of pests.

An exhibit composed of samples of some half a dozen of the chief spraying materials is inexpensive and valuable. Without something to see all elementary science teaching falls short. Classification of pests into biting and sucking insects should be followed by classification of the sprays into "stomach poisons" and "contact remedies."

The farmer's insect allies as well as his enemies deserve an introduction to students. It is as interesting and valuable to know how lady beetles destroy plant lice as to know how plant lice destroy garden crops. The agricultural classic story of the successful search in Australia by our United States Department of Agriculture for the predacious insect that is the natural check of the cottony cushion scale furnishes a good example of how science may cooperate with nature to accomplish what man alone could not do with his sprays and poison gases.

Under the larger unit of study which might be labeled "Man's Insect Enemies and Allies" the sub topic of honey bees should not escape the notice of the general science teacher looking for phases of nature that will interest children and possess cultural value. Writers of fiction have not failed to see the appeal in the story of life within the hive, as is evidenced by Maeterlinck's "Life of the Bee" and Kipling's "The Mother Hive."

An observation hive of a single frame and two glass sides brings our topic into the realm of observational studies. Set in a window with an exit for the bees arranged so that the window itself is between the observer

and any loose bees our study of their habits is safe.

If we wish to make the study merely esthetic we may use Margaret Morley's "Bee People" as reference. If, for older pupils, we care to make it vocational we may secure a bulletin on bee keeping from the U. S. Department of Agriculture or from our State Experiment Station.

Another agricultural topic which may well be transplanted into the field of general science is the propagation of plants. Cuttings started in water or in sand help to make the topic objective. Radish seeds germinated between two pieces of blotting paper, one of which dips into water, develop abundance of root hairs.

The phase of the subject most likely to arouse interest, and enlist individual effort at home by way of experiment is grafting and budding. For class discussion we have such topics as the union of cambium layers, and the principles by which the character of the fruit in an orchard can be fixed, and the failure of many kinds of seed to "come true" to type. For class demonstration and suggested home work practice in budding, and perhaps the more difficult process of grafting, should be sufficient to challenge effort and interest.

A sufficient reward to lure youngsters looking for scientific worlds to conquer is the possibility of making red and white roses grow on the same bush.

FLUIDS IN MOTION.

By Adren Aitken,

Tamalpais High School, Mill Valley, Calif.

A very interesting application of the law of conservation of energy can be found in the study of a continuous stream of moving fluid. The discovery of this application was made by Daniell Bernoulli (1700-1782), of the famous Bernoulli family. Stated briefly, Bernoulli's discovery is as follows:

"In a stream of moving fluid the pressure is greatest in the wide portions of the stream where the velocity is least and is least in the narrow portions of the stream where the velocity is greatest."

Before the time of Bernoulli it was not definitely known that besides the energy of motion or kinetic energy possessed by a moving fluid there is also energy of pressure or potential energy which is also acting. The sum of these two energies may be

expressed mathematically as follows:

$$PV + \frac{Wv^2}{2g}$$ where P = pressure.
V = a unit volume of constant density.
and PV = potential energy.
$\frac{Wv^2}{2g}$ = kinetic energy.

Now, because of the law of conservation of energy, the total energy in a unit volume of moving fluid at any point, is equal to the total energy possessed by the same fluid when it reaches some other point, if we disregard friction. Therefore we may write:

$$P_a V + \frac{Wv_a^2}{2g} = P_b V + \frac{Wv_b^2}{2g}$$

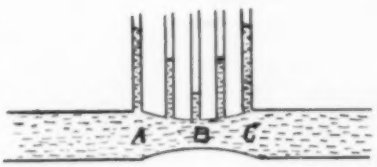


FIGURE 1.—FLOW OF WATER THROUGH A CONSTRICTED PIPE. THE PRESSURE IS LEAST WHERE THE SPEED OF THE WATER IS GREATEST.

By referring to Figure 1, we see that the velocity of the fluid (v_a) at *a* is less than the velocity (v_b) at *b*. Therefore the energy of motion $\frac{(Wv_a^2)}{2g}$ of the fluid at *a* is smaller than the energy of motion $\frac{(Wv_b^2)}{2g}$ of the fluid at *b*. But we have seen that the total energy at *a* must be equal to the total energy at *b*. This apparent inconsistency was first explained by Bernoulli. It was he who pointed out that the energy of pressure at *a* is greater than the energy of pressure at *b* and that this difference makes the left hand side of the equation above equal to the right hand side as it should be.

Thus we have seen that in a continuous flow the law of conservation of energy requires that the potential energy or the energy of pressure increases as the kinetic energy or energy of motion decreases to keep the energy content per unit volume constant. To restate Bernoulli's principle in a slightly different form we have:

"In a stream of moving fluid the pressure is greatest where the velocity is least and is least where the velocity is greatest."

Bernoulli's principle can be illustrated in many ways. For example, contrary to expectation, two parallel sheets of paper having a stream of air blown between them come together. That is, because the stream of air loses pressure and since the

pressure between them is less than the pressure outside, the two pieces of paper come together.

Here is another simple experiment illustrating Bernoulli's principle. Stick a pin through a card and insert in a spool as shown in Figure 2. Blow through the spool and at the same time remove your finger. The card remains close to the end of the spool, in spite of the fact that one would expect both the stream of air and gravity to force it away. The explanation is simple: The air passing between the card and the spool at high speed reduces the pressure while on the lower side of the card the air remains at atmospheric pressure. The upward force resulting from the difference in pressure is more than the weight of the pin and the card.

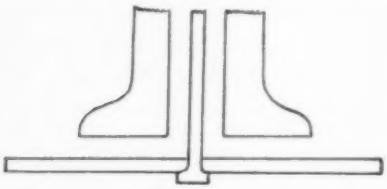


FIGURE 2.—THE CARD IS HELD TO THE SPOOL BECAUSE THE CURRENT OF AIR REDUCES THE PRESSURE BETWEEN THE CARD AND THE SPOOL.

Probably the most interesting experiment of all is the case of a ping pong ball supported in a narrow vertical jet of air. (A vertical stream of water will do just as well.) Once the stream surrounds the ball, the pressure of the air on the lower half of the ball is less than on the upper half because the velocity of the air past the lower half is greater than past the upper half. The result is, that the ball is kept down in the stream to a point where the force of the air upward is equal to the weight of the ball and the pressure of the more slowly moving air from above. The fact that the pressure is greater on the outside than on the inside of stream also serves to keep the ball in the stream, because once the ball begins to work out, the greater air pressure on the side toward which it is working forces it back into the stream.

FIGURE 3. — A PING PONG BALL SUPPORTED IN A VERTICAL STREAM OF AIR.

When two ships are moving in the same direction there is great danger of a broadside collision unless they are some distance apart. Even when the distance appears to be safe, the ships move sideways toward each other as though sucked together by some irresistible force of attraction.

The vessels moving parallel to each other through the water is equivalent to a stream of water flowing through a constriction, the sides of the vessels forming the sides of the constriction. Therefore, the pressure between the vessels is decreased. Since the pressure on the opposite sides of the vessels remains practically unchanged, the vessels move toward each other because of the unbalanced forces on their sides.

The Venturi meter, which is a device for measuring the speed of water in pipes, is based on Bernoulli's principle. In Figure 4 it is shown that one annular chamber surrounds the entrance to the meter and another one at the throat. Pressures in the pipe are transmitted to these chambers through small holes in the wall of the pipe. These are connected to a gauge filled with mercury. The difference in level of the two mercury columns is a measure of the difference in pressure between the entrance and the throat of the meter. Then by knowing the difference in pressure, we can with Bernoulli's equation calculate the speed of the water in the pipe.

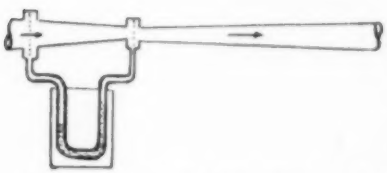


FIGURE 4.—THE VENTURI METER.

The Pitot tube operates on the same principle as the Venturi meter. This instrument can be used for measuring the air speed of airplanes and balloons, the speed of air in wind tunnels, etc.

In the Bunsen burner the gas is admitted through a very narrow jet; and on each side of the jet are large circular openings through which air is admitted. The gas, as it emerges from the jet, has considerable velocity and therefore the space around it is a region of low pressure, which causes a steady stream of air to enter through the openings at the bottom of the tube. On reaching the top of the tube the gas and air are uniformly mixed. The rate at which air enters the burner is regulated by adjusting the size of the air inlets.

The burners used in gas stoves and ovens are identical in construction and principle with the Bunsen burner.

When a baseball is thrown so that it does not spin it generally travels in a straight line. But every boy knows that a spinning ball will move along a curved path. If we refer to Figure 5 we shall find that the explanation is quite simple. The spinning ball drags the adjacent air around with it. At the top of the ball this air is moving with the air current set up by the forward

motion of the ball, and at the bottom it is moving against the current. The air at the top moves faster and the pressure there is reduced. the air at the bottom moves slower and the pressure there is increased. Thus, the ball will move along the curved path shown in Figure 5. The secret of how to throw a certain curved ball is learned when the pitcher learns in what direction to spin the ball as it leaves his hand. But you must remember that knowing how and being able to do are two different things. A knowledge of Bernoulli's principle will not make a great pitcher but it will help.

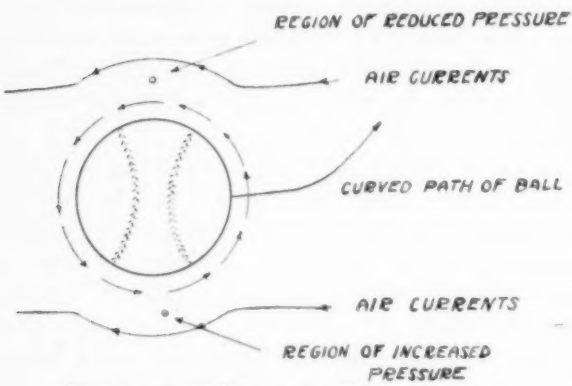


FIGURE 5.—WHY A BASEBALL CURVES.

You may go to the library and look up the construction of a boomerang. Then hand in a written explanation of its peculiar action when thrown by an expert in terms of the principle which we have been studying.

An aspirator is a form of air pump attached to a water faucet. It is used in the chemistry laboratory as an aid in the separation of liquids and solids. Hence the name filter pump. It is also used by doctors in order to remove the saliva and blood from the mouth during a throat operation. It has many other uses.

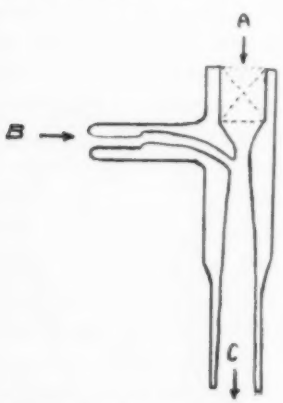


FIGURE 6.—A FILTER PUMP.

In the filter pump shown in Figure 6, the water from the faucet enters at A. As the water moves through the narrow channel or constriction its pressure is decreased very much below atmospheric pressure. This is a consequence of Bernoulli's principle. Accordingly the air is drawn in of the through the side tube B and carried out at C by the rush water.

The atomizer is commonly used for spraying disinfectants and perfumes. Recently it has found a wide application as a paint spray.

In the paint spray, a pint jar is used as a container for the liquid paint. A metal tube, which is soldered into the lid of the jar, dips into the paint. Near the top of the tube is a constriction and above this constriction a current of air emerges from the end of a horizontal tube. Now, we have learned from Bernoulli that where the velocity is great the pressure is small and since the top of the vertical tube is in this region of diminished pressure the liquid paint is lifted to the top and blown off in fine drops or spray by the current of air.

The top of a chimney in a wind is exactly like the vertical tube in the paint spray. But instead of paint, smoke is lifted to the top and blown away. When the wind blows directly across the top of the chimney the draft is improved. A forced draft is secured if the wind takes an upward cut past the top of the chimney. Any downward slant of the wind past the top of the chimney militates against a good draft.

If the man in the street is asked what lifts an airplane he is likely to say that it is the pressure of the air upward on the undersurface of the wing. As a matter of fact this upward force supports only about a quarter of the total weight of the plane. The air underneath the wing experiences little change in velocity. But the air above the wing has to undergo an increase in velocity because it must travel the longer distance over the top of the cambered wing. Therefore, according to Bernoulli, there will be a decrease in pressure of the air above the wing. This region of decreased pressure above the wing is mainly responsible for the lift of the wing—about three quarters of the total weight of the plane.

Sometimes the air stream does not follow closely over the top of the wing which allows eddy currents to form between the wing and the air stream. When this happens the wing stalls. That is, the wing loses its lifting power and the pilot is due for a "crack up" if he is too close to the ground. Many experiments have been tried in order to discover some successful method of bringing a lost air stream back to the surface of the wing. At present the Handley Page automatic slot seems to be the nearest solution. The beneficial effect of this invention can be partly explained by the Bernoulli effect and the deviation of the air stream due to the down wash from a special auxiliary air foil.

AN ADJUSTABLE DIFFRACTION GRATING.

By R. William Shaw,

Cornell University, Ithaca, New York

For an appreciation of many of the phenomena, such as X-ray diffraction by crystals and electron diffraction, upon which modern physical theories are based, it is essential that science students have a clear understanding of the diffraction of visible light. Many diffraction experiments require only the simplest apparatus, and they may profitably be undertaken in a qualitative way by beginning students of science. As examples of such experiments one may consider the diffraction phenomena produced by needles, razor blades, and slits. Fortified by a thorough acquaintance with the physical facts, the student is able to follow the theoretical interpretation of diffraction readily enough as soon as he has received the necessary mathematical training.

One very important fault with such experiments is the failure of students to clearly understand the relation of single and double slit diffraction patterns to that of a large grating such as is used with a spectrometer. Possibly this failure is due to a lack of adequate apparatus with which to make the transition, and it is to meet this need that the writer has designed and used the adjustable grating described below. In this device the experimenter has control of the following important factors of diffraction gratings:

1. The total number of openings used.
2. The width of the openings.
3. The width of the opaque spaces between the openings.

In order to obtain the desired results a modified form of wire grating is used. Figure I shows front and side views of the apparatus. The main part consists of a pair of brass knife edged plates A mounted in suitable guides. Each of the guides is held in place by three screws C which are allowed to extend through the main support for about one quarter of an inch. On each of the knife plates is a small knob which facilitates adjustment. A micrometer screw may be used but it is not at all necessary. With these adjustable knife edges single slit and straight

edge diffraction experiments may be carried out.

Above and below the slit arrangement are soldered semi-cylindrical brass rods B which have been threaded. In the particular apparatus described forty-eight threads to the inch were used.

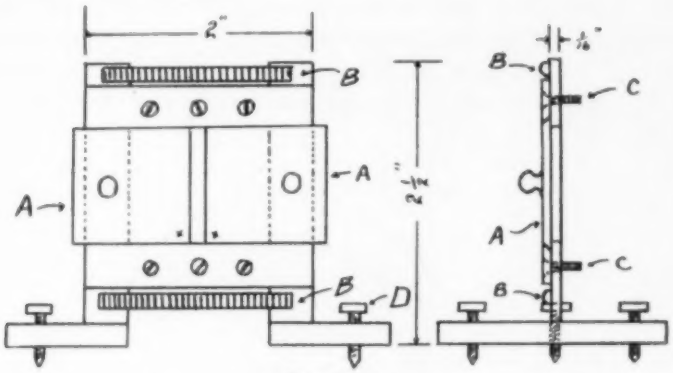


FIGURE 1

A—ADJUSTABLE PLATES WITH KNIFE EDGES (xx).
B—HALF-ROUND THREADED RODS.
C—SCREWS HOLDING KNIFE EDGE GUIDES, AND SERVING AS ANCHORS FOR THE GRATING WIRES.
D—LEVELING SCREWS.

If a double slit arrangement is desired, all that one has to do is to fasten one end of a fine wire to an upper post C, pass the wire through a groove in rod B, pull it tightly over the face of plate A, pass it around the other rod B, and fasten the end to a lower post C. By properly adjusting the knife edges with respect to this wire a fine double slit is obtained. It will be observed that the width of the slits depends on the adjustment of the knife edges and the width of the opaque space on the diameter of the wire.

In order to obtain three slits the wire is simply placed in an adjacent groove of B, passed over A in the reverse direction, and the end again twisted around C. The extension of this procedure to form any number of slits is obvious.

It is clear from the method outlined that the width of the opaque space is limited by the diameter of the wire used. This difficulty may be easily overcome by using the following scheme. In Figure 2, E represents a cross section of the threaded rod B, and F cross sections of wires

placed in the grooves. The figure represents the case when two adjacent wires form a groove in which a third wire is placed in order to close the opening between the first two. The addition of the third wire produces a much wider opaque space than could possibly be obtained with a small single wire. For still wider spacing the same procedure is continued in the successive grooves. Copper wire serves very well in making the grating, but it should be pointed out that it is essential to make the wires very taut across the face A.

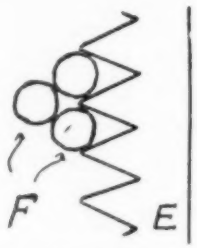


FIGURE 2

Only over-all dimensions have been given in the figure since the relative sizes of the parts may vary considerably. It is important that the radius of the rod B be not greater than the thickness of the guides holding the knife edges A as otherwise the wires will not be flush with the face of A.

In conclusion it may be stated that this device has proved to be of pedagogical value in as much as it permits the student to investigate in successive steps the diffraction phenomena of slits and straight edges. At the same time all of the variable factors from the simplest case to a completed grating are under his control.

BLOOD TESTS OF PATERNITY.

Blood group tests to determine a child's paternity should not be made until at least two weeks after birth, Dr. Carl H. Smith of Cornell University Medical College advises in a note to the American Medical Association.

Dr. Smith has found from a study of blood groupings that for the first ten days or so the infant's blood group is influenced by the direct transmission before birth of some of the mother's blood. After that period, the child's own blood group becomes fully established and a fair, reliable test can be made.—*Science Service.*

ASPECTS OF THE HIGH SCHOOL SCIENCE CLUB MOVEMENT.

By LOUIS A. ASTELL,

Research Associate, Institute of School Experimentation, Teachers College, Columbia University, New York City.

Science clubs and high school clubs relating to other subjects have been found useful by many teachers. Also, some who have tried one plan or another for development of clubs have not found them useful. The Institute of School Experimentation is endeavoring to find what types of club plans and procedures can be expected to produce worthwhile results. Mr. Astell has been appointed to cooperate with certain high schools in the study of this question. As a part of his study he wishes to make record of all such work. The following statement outlines part of his work. He will appreciate information from all possible sources regarding science clubs that have been or are now in existence.—Otis W. Caldwell, Director.

For a number of years, science clubs of various types have held a more or less inconspicuous place among the activities of the high school. The fact that these clubs have functioned in an intermittent and a sporadic fashion is evidence of a variety of problems involved in the establishment and operation of genuinely successful clubs. For instance, contrast the potentialities of a science club in an average rural community high school with a similar club in any high school of New York City. In the first case, the benefits of community life, scientific equipment, and reference libraries, are likely to be at or near a minimum. In the second, there is a wealth of contributing organizations, museums, industries founded on science, and other supplementary facilities, immediately available. On the other hand, the smaller system is likely to offer fewer and less serious difficulties in the organization and management of the club. Only those teachers who have had intimate contact with the two types of situations can realize the difference involved.

A specific problem of consequence to every club is that of desirable means for the maintenance of the highest type of interest. In this connection, the early work of Doctor Morris Meister[1] is suggestive. His credit system represents one of several methods. Problems involving statistical aspects of science clubs have been the basis of a very helpful study by Doctor Hanor A. Webb[2]. At this time there is a definite need for correlative work

[1]Meister, Doctor Morris, "Managing a Science Club," SCHOOL SCIENCE AND MATHEMATICS, 23: 205-217, March, 1923.

[2]Webb, Doctor H. A., "Some First Hand Information Concerning Science Clubs," SCHOOL SCIENCE AND MATHEMATICS, 29: 273-276, March, 1929.

with detailed evidence as to the trend in organization.

In recognition of the obligations accompanying the possession of science knowledge, important scientific bodies of this country have been at work on the problem of relations with high school students. In 1919, the Illinois State Academy began offering institutional affiliations to high school science clubs'. With the establishment of a Junior Academy, the activity has spread over the state. The junior clubs are definitely related to the pupil's incentives. The dignity of a self-supporting basis has been developed. The progress made in the past year is indicated by the affiliations which are five times the number for any single preceding year. Several other State Academies of Science are preparing to develop similar plans.

Since 1923, the American Association for the Advancement of Science has had a special committee on "The Place of Science in Education."[3] It is peculiarly fitting that the study of the science club as an agency in education has come under the surveillance of this body.

The latest development, perhaps, is that the American Institute of the City of New York, composed of leaders in civic, industrial, and scientific affairs, has adopted a plan for junior memberships.[5] As other important organizations provide for and develop active relationships with reference to science clubs, we may expect to have greater benefits.

The high school science club, as an aid in furthering scientific education, has been subjected to a relatively small amount of inquiry. Results from the appended outline may represent a useful contribution. It is planned as a purely cooperative project since science clubs when developed to a maximum for given situations appear to be rich in promise.

For Administrators or Science Teachers

The following outline is designed for use with a minimum amount of effort by any teacher who is associated with any kind of science club. Each teacher who will

[3]Astell, Louis A., "How State Academies of Science May Encourage Scientific Endeavor Among High School Students," Science, 71: 445-449, May 2, 1930.

[4]Chairman, Doctor Otis W. Caldwell, 433 W. 123rd St., New York City.
[5]Secretary, Mr. William Crocker, 250 W. 57th St., New York City.

submit complete data on a given club, whether it is in existence at this time or not, will receive a tabulated summary of results, providing the return address is included.

A. SCHOOL:
   1. Location:
      i —urban,
      ii —suburban,
      iii—rural,
   2. Enrollment:
      i —total number,
      ii —number in science department or departments related to principal interest or interests of the club,

B. SCIENCE CLUB:
   3. Membership:
      i —total number,
      ii —number of boys,
      iii—number of girls,
   4. Science or sciences of principal interest,
   5. Year of organization,
   6. Activity:
      i —non-existent since ————,
      —reasons:
      ii —more or less nominally existent,
      —reasons:
      iii—is a comparatively effective organization,
      —reasons:
   7. Meetings:
      i —hour,
      ii —length,
      iii—number per month,
   8. Relationships:
      i —inter-mural,
      ii —extra-mural,
   9. Objectives:
      i —major,
      ii —minor,
   10. Outline of a typical program,
   11. Rewards,
   12. Insignia,
   13. Number of similar school organizations functioning throughout the academic year,

C. THE SPONSOR:
   14. Brief outline of teaching load,
   15. Additional duties related to the school.

An oak tree with 750,000 leaves will in five months evaporate 200 tons of water. An acre of early cabbage will give off over 100 tons of water during the last month of growth.

Cape Cod Section produces over half a million barrels of cranberries each year, which are shipped partly green in order to stand up during transit. The house-wife never is able to buy vine-ripened berries. Vine-ripened berries are too tender to ship fresh.

ACHIEVEMENT TEST IN PHYSICS AT THE UNIVERSITY OF KENTUCKY.[1]

By Prof. M. N. States,

Department of Physics, Lexington, Ky.

For a number of years the Department of University Extension of the University of Kentucky has been conducting achievement tests among the high schools of the state of Kentucky. To accomplish this, the high schools of the state are divided into sixteen groups. On a Saturday in April, representatives from the various high schools meet at sixteen different centers in the state and take tests in various subjects. The tests are prepared under the direction of the Department of University Extension and are of the objective type. Students who take first place in each subject in each district subsequently present themselves for the final round of the tournament at the University. By an additional testing procedure the "best student" in each subject is selected.

In the spring of 1930, the Department of Physics of the University, cooperating with the Department of University Extension, had a part in this contest and selected the state champion in physics. The department prepared an examination which was given to some eighty students in the various districts. Inasmuch as students were permitted to participate in more than one contest the test was limited in the amount of time required for its administration. For this reason the examination was of the true-false type. In this way a representative from each of the sixteen districts was selected and they appeared for final examination at the University on April 10, 1930.

In the final examination in physics, an attempt was made to test the student's ability to observe events accurately and carefully, as well as to test knowledge of subject matter. To this end, an experiment was performed before the class, repeated a number of times, but without the usual accompanying remarks. The experiment involved the laws of motion, momentum and energy relations, a knowledge of magnetism and electricity. It was not expected that any one student would be able to analyze all of the elements in-

[1] This plan has awakened a lively interest in Physics on the part of pupils in high schools throughout Kentucky. It is worthy of imitation in other states.—Ed.

volved in the experiment, but certain leading questions having been raised, it was expected that the test would give information on the student's ability to observe and at the same time test his knowledge of physics. In addition, informational questions were asked and each student was asked to solve a set of examples in physics. When the results were tabulated, it was found that one student was outstanding, and that two students of equal rank were next in line. The student for second place was then arbitrarily selected on the basis of ability to solve the problems of the test.

One of the stimulating factors in the contest was the fact that the Central Scientific Company offered as a prize a piece of apparatus to the high school who trained the winning student. In addition, the Department of University Extension presented the winning student with a gold medal.

The student who won the first prize in physics also ranked first in the contest for all-around scholastic standing. It is an interesting fact that on a subsequent date, using examinations prepared and administered by a different group of individuals, a student from the high school whose representative won the prize in physics was selected to represent the state of Kentucky in the Edison contest. It is also significant that in a survey now being made by Mr. William Harris, and which has not yet been published, he finds that this high school also ranks highest in the state in the matter of its product in physics. This ranking is based upon the standing made by students from the various high schools of the state who subsequently took physics in the University. Records covering a seven year period were studied, and the records of students from the twenty high schools sending the largest number of students to the University and who took physics in the University, were analyzed.

It is hoped that a similar contest may be carried out this year. Perhaps a slightly different procedure may be followed in making the selection, inasmuch as the high schools of the state present the several divisions of physics in different orders. It would seem to be a bad practice to foster any scheme of testing which would induce a high school to

deliberately train students for a contest instead of following the best procedure for giving the student a thorough training in the subject. In any event, with certain modifications it is hoped that the plan of having the contest may be continued and that it may be a means of stimulating interest in physics among both the teachers and students in the high schools of the state.

YOUNG'S MODULUS FROM A FOUCAULT PENDULUM.

By Noel C. Little,

Bowdoin College, Brunswick, Me.

The proposed method of determining Young's Modulus is dynamic in contrast with the usual static methods of measuring directly the elongation produced by a given stretching force. Sommerfeld has discussed such a dynamic method of determining the elastic properties of wires by studying the oscillations of a spring made from them (cf. "Resonance Spring" of the Central Scientific Company). In general, however, the theory of these methods is too involved for elementary classes in Physics. The following method, discovered while setting up a demonstration of Foucault's Pendulum, permits of a simple analysis.

A simple pendulum hung in a hallway near a flight of stairs may be made 30 ft. or more in length by extending it through the height of two floors. The heavy bob (5 to 10 lbs.) is supported by a steel or brass wire (0.01 to 0.02 in. in diameter). Such a bob shows in addition to its slow horizontal swings much more rapid vertical oscillations. These latter are due to the periodic stretching and recovery of the wire and the number occurring during a complete horizontal swing of the pendulum may be readily counted. Young's Modulus for the material of the wire is then given by the square of this number times the weight of the bob divided by the cross section of the wire.

Illustrative data follow:

Material	Wt. of Bob	No. in 5 Swings	Dia. Wire
steel	4.53 lb.	98	0.0100 in.
brass	4.53 lb.	86	0.0139 in.

Computation of Young's Modulus from the above data:

steel $\dfrac{98\times98\times4.53\times4}{5\times5\times3.14\times0.01\times0.01}=22$ million lb./in^2.

brass $\dfrac{86\times86\times4.53\times4}{5\times5\times3.14\times0.0139\times0.0139}=8.8$ million lb./in^2.

In discussing the theory the following nomenclature will be used:

w weight of bob
l length of pendulum
A cross-section of supporting wire
x and y horizontal and vertical displacements, respectively, of the bob from its equilibrium position.
t the period of the horizontal swings
t' the period of the vertical oscillations
n no. of vertical oscillations during one complete horizontal swing over and back.
g acceleration of gravity
F displacing or restoring force
Y Young's Modulus

n is readily seen to be equal to $t \div t'$

t from the familiar formula for the period of a simple pendulum is given by

$$t = 2\pi\sqrt{l/g}$$

It is, however, instructive to think of this formula as a special case of a more general formula which applies to the free undamped period of small oscillations about a position of equilibrium of any physical system. Such a formula is

$$t = 2\pi\sqrt{\frac{\text{inertia factor}}{\text{stiffness factor}}}$$

In our problem the inertia factor for both the horizontal and vertical oscillations is the mass of the bob, w/g. The stiffness factor is the ratio of the restoring force to the displacement from the equilibrium position, *i. e.*, F/x for the horizontal motion and F/y for the vertical. F for the horizontal motion acts at right angles to the supporting wires and is the component of the weight of the bob in that direction. From the theory of simple statics this is seen to be $\frac{x}{l}w$. The stiffness factor then becomes $\frac{w}{l}$ and the complete expression under the radical $\frac{w}{g} \div \frac{w}{l}$ or l/g as was to be expected.

F for vertical motion comes from the definition of Young's Modulus, i. e.,

$$Y = \text{stress} \div \text{strain} = \frac{F}{A} \div \frac{y}{l}$$

Thus the stiffness factor for the vertical motion is

$$\frac{F}{y} = \frac{YA}{l}$$

and the period of this motion

$$t' = 2\pi\sqrt{\frac{wl}{gYA}}$$

but

$$n = \frac{t}{t'} = \sqrt{\frac{AY}{w}}$$

or solving for Young's Modulus

$$Y = n^2\frac{w}{A}, \text{ the required formula.}$$

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTION.

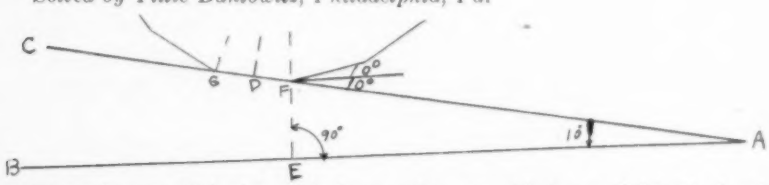
1122. *Solved by Lu Chin-Shih, Soochow Univ., Soochow, China.*

SOLUTION OF PROBLEMS.

1127. *Proposed by Richard Corsan, Indianapolis, Ind.*

A regular polygon just tumbles down an inclined plane whose inclination is 10°. How many sides has the polygon?

Solved by Tillie Dantowitz, Philadelphia, Pa.



The polygon will just tumble down, when one side is parallel to the level ground, while another adjacent side is on the plane. This polygon then makes a 10° angle with the inclined plane. Using the theorem: "The sum of the exterior angles of a polygon is 4 rt. angles," and noting that all the exterior angles are equal, we have $20\,n = 360°$. $n = 18$.

This also means that the line from the center of the polygon to the lower vertex on the plane is $\perp$ to the horizontal. Hence, when in this position, the polygon is in neutral equilibrium.

Also solved by *James C. Loughman, Leetsdale, Pa.; Louis R. Chase, Newport, R. I.; George T. Johnson, Brainerd, Minn.; Albert Schwartz, Perth Amboy, N. J.; Sudler Bamberger, Harrisburg, Pa.;* and *J. F. Howard, San Antonio, Texas.*

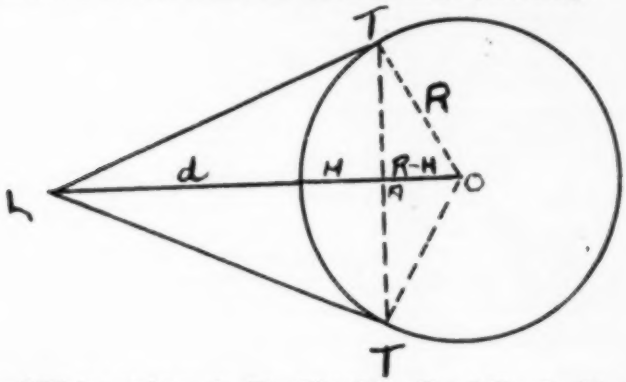
1128. *Proposed by Helen Beatty, Denver, Col.*

Show that the area of a zone of a sphere of radius R illuminated by a lamp placed at the distance d from the surface is

$$\frac{2\ \text{pi}\ R^2 d}{R+d}$$

Solved by Albert Schwartz, Perth Amboy, N. J.

Let H be the altitude of the zone TT illuminated by the lamp.

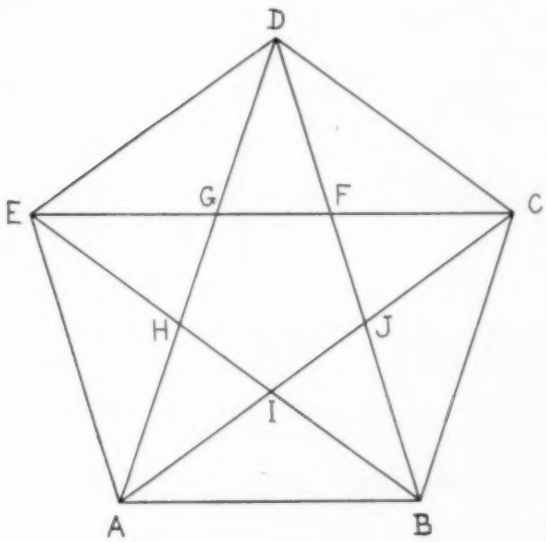


Since OTL is a right angle, $R^2 = OL \times OA = (R+d)(R-d) = R^2 - HR + Rd - Hd$. Hence $H = Rd/(R+d)$. The area of a zone of altitude H is 2 pi RH. Hence,

$$\text{Area of the zone} = \frac{2\ \text{pi}\ R^2 d}{R+d}.$$

Also solved by *Louis R. Chase, Newport, R. I.; Melvin Dresher, Hackensack, N. J.; R. T. McGregor, Elk Grove, Calif.; W. E. Buker, Leetsdale, Pa.; J. F. Howard, San Antonio, Texas;* and by *Sudler Bamberger, Harrisburg, Pa.*

1029. *Proposed by Norman Anning, University of Michigan.*



In the regular pentagon ABCDE is inscribed the regular pentagram ACEBD. Show that, if we count twice the area which is surrounded twice, the area of the pentagram divides the area of the pentagon in golden section, i. e., in the ratio $(\sqrt{5}-1) : 2$.

Solved by Louis R. Chase, Newport, R. I.

Let this ratio be designated by r. Any two diagonals of a regular pentagon cut each other in extreme and mean ratio, each of the larger segments being equal

to a side of the pentagon. (*Euclid XIII—8*). From this it is easily deducible that in the figure there are 4 sets of equal segments such that the ratio of any of the smaller to one of the next larger is r.

There are 5 sets of congruent triangles. Since the areas of triangles having equal altitudes are to each other as their bases, it follows from the position of the triangles that if

each triangle such as ABD be taken as unity,
each triangle such as AJD $= r$,
each triangle such as BCF $= r^2$,
each triangle such as FCD $= r^3$, and
each triangle such as BJI $= r^4$.

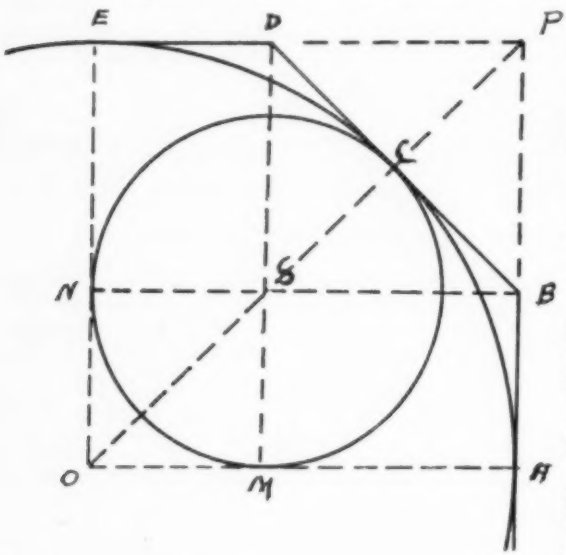
$$\frac{\text{Pentagram} + \text{small pentagon}}{\text{Large pentagon}} = \frac{\text{AJD} + \text{EIC} + \text{BJI}}{\text{ABD} + (\text{ADE} + \text{BCF}) + \text{FCD}} =$$

$$\frac{r + r + r^4}{1 + 1 + r^3} = r.$$

1030. *Proposed by the Editor.*

Prove: The diameter of a circle inscribed in a quadrant of a second circle is equal to the side of the regular octagon circumscribed about the second circle.

I. Solved by Lu Chin-Shih, Soochow Univ., Soochow, China.



(1) AB and ED are produced to intersect each other at P.

(2) From B draw BN ∥ PE; and from D draw DM ∥ PA.

∵(3) ABCDE . . . is the circumscribed regular octagon.

∴(4) PE = PA, DE = DC = BC = BA, since they are tangents to the ⊙o from the points P, D and B respectively.

∵(5) (PE − DE) = (PA − BA); i. e. PD = PB.

∴(6) BPDS is a square, since BN ∥ PE, DM ∥ PA, PD = PB, and ∠BPD has been known a rt. ∠.

(7) The vertex O of the square APEO and the vertex S of the square BPDS are collinear with the common vertex P.

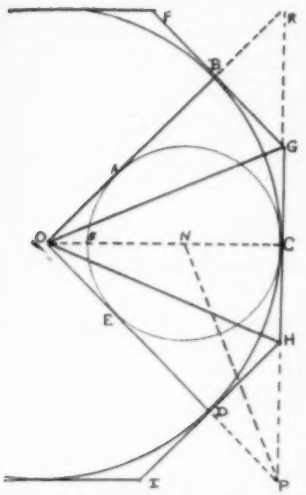
(8) In the rectangles ABSM and NSDE, SM = BA and SN = DE. Since DE = BA, SM = SN.

(9) In the square BPDS, SC = BC. Since BC = BA, SC = SM = SN.

∴(10) The center of the inscribed circle must lie on S, and SC = r, the radius.

∴(11) The diameter $2r = 2SC = 2BC = BC + DC = BD$, the side of the regular octagon.

II. *Solved by Robert Meyers, Creighton Univ., Omaha, Neb.*



Given: The circle CAE, with center at N, inscribed in the quadrant BOD, of the circle BCD, with center at O, the first circle being tangent to the perpendicular radii, BO and OD, at A and E, respectively; the regular octagon, FGHIJKLM, circumscribed about the circle BCD, with the sides, FG, GH, and HI, tangent to the circle at B, C, and D, respectively.

To prove, that 2CN, or CS, the diameter of the first circle is equal to GH, one of the sides of the octagon.

Proof:

1. Extend GH in both directions to meet OB and OD extended, in R and P, respectively.
2. Therefore, Circle ACE is tangent to RP at C (construction).
3. Furthermore, the center, N, of circle CAE, is on the bisectors, OC and PN, of angles ROP and OPR, respectively (construction of an inscribed circle).
4. $\angle BOC$ is equal to $\angle COD$.
   $\angle BOC$ is equal to $\angle BOG$ plus $\angle GOC$
   $\angle COD$ is equal to $\angle COH$ plus $\angle HOP$
   Therefore, $\angle BOG$ plus $\angle GOC$ is equal to $\angle COH$ plus $\angle HOD$.
5. But $\angle BOG$ is equal to $\angle HOD$. (Congruent right triangles).
   Therefore, $\angle GOC$ is equal to $\angle COH$.
6. $\angle OCH$ is equal to $\angle NCP$ is equal to 90°.
7. $\angle ROP$ is equal to 90 degrees.
   $\angle ORC$ is equal to $\angle OPC$ is equal to 45 degrees.
   Therefore, $\angle CPN$ is equal to 22½ degrees.
8. Since n equals 8, $\angle GOH$ equals 45°, and $\angle COH$ is equal to 22 ½°
   Therefore, $\angle COH$ is equal to $\angle CPN$.
9. Since $\angle COP$ is equal to $\angle CPO$, CO is equal to CP.
10. Therefore, $\triangle OCH \cong \triangle PCN$. (One side and 2 adj. angles of 2 triangles.)
11. Therefore, NC equals CH equals ½ GH. (Corresponding sides of congruent triangles.)

So, 2NC equals CS equals GH.

Also solved by *Tillie Dantowitz, Philadelphia, Pa.; Louis R. Chase, Newport, R. I.; F. A. Cadwell, St. Paul, Minn.; Albert Schwartz, Perth Amboy, N. J.; Sam Nelken, New Orleans, La.; J. F. Howard, San Antonio, Texas;* and by *W. E. Buker, Leetsdale, Pa.*

1031. *Proposed by E. de la Garza, Brownsville, Texas.*

Find the sum of n terms of the series

$1+8+19+34+53+76+\ \ldots\ldots$

I. *Solved by Louis R. Chase, Newport, R. I.*

$n=1, 2, 3, 4, 5, 6,$ etc.

S = 1, 9, 28, 62, 115, 191, in which the third differences are constant.

Therefore $S=f(n)=an^3+bn^2+cn+d$. (1)

Substituting corresponding values of n and S from the table above, and solving the resulting simultaneous equations, we have $a=2/3$, $b=3/2$, $c=-7/6$, and $d=0$.

Substituting these values in (1), and simplifying, we have

$S=1/6\ (4n^3+9n^2-7n)$.

II. *Solved by F. A. Cadwell, St. Paul, Minn.*

Let the scale of relation be $1-Px-Qx^2-Rx^3$, then

$$R+8Q+19P=34$$
$$8R+19Q+34P=53$$
$$19R+34Q+53P=76.$$

Solving this set of equations: P = 3, Q = −3, R = 1. Hence, the scale of relation is $1-3x+3x^2-x^3$. From this scale of relation, the generating function is found to be

$$S=\frac{1+5x-2x^2}{(1-x)^3}=\frac{-2}{1-x}-\frac{1}{(1-x)^2}+\frac{4}{(1-x)^3}$$
$$=-2(1+x+x^2+x^3+\ldots)-(1+2x+3x^2+4x^3+\ldots)$$
$$+4(1+3x+6x^2+10x^3+\ldots)$$

Sum each series to N terms and setting $x=1$, we get

$$S=-2n-n(n+1)/2+2n(n+1)(n+2)/3$$
$$S=\frac{n(4n^2+9n-7)}{6}$$

III. *Name of Solver not on paper sent in.*

Let us write the series whose rth term is the sum of the first r terms of the given series, thus,

1, 9, 28, 62, 115, 231, ...

To solve the problem it is necessary to obtain an expression for the nth term of this derived series.

Let us write the following difference table:

a	$f(a)$	$\Delta f(a)$	$\Delta^2 f(a)$	$\Delta^3 f(a)$	$\Delta^4 f(a)$
0	0				
		1			
1	1		7		
		8		4	
2	9		11		0
		19		4	
3	28		15		0
		34		4	
4	62		19		0
		53		4	
5	115		23		
		76			
6	231				

We now apply Newton's interpolation formula, which is

$$y=f(a)+n\Delta f(a)+\frac{n(n-1)}{2!}\Delta^2 f(a)+\frac{n(n-1)(n-2)}{3!}\Delta^3 f(a)+\ldots\ldots\ldots$$

Applying Newton's formula to the above difference table, we get

$$f(n)=0+n+7\frac{n(n-1)}{2!}+\frac{4n(n-1)(n-2)}{3!}=\frac{n(4n^2+9n-7).}{6}$$

Also solved by *Marquess Wallace, Mexico, Mo.; R. T. McGregor, Elk Grove, Calif.; Melvin Dresher, Hackensack, N. J.; Tillie Dantowitz, Philadelphia, Pa.;* and by *George T. Johnson, Brainerd, Minn.*

1032. *Proposed by Ruth Laken, Detroit, Michigan.*

Prove: The right cone, whose slant height is to the radius of base as 3 : 1 has the maximum volume within a given surface.

Solved by Tillie Dantowitz, Philadelphia, Pa.

Let L, R, H be the slant height, radius, and altitude respectively. Surface = K = pi RL + pi R^2. V = 1/3 pi R^2H.

Let L = kR, then $H^2=R^2(k^2-1)$, and K = pi(kR^2+R^2)

$$V^2=1/9\ \text{pi}^2R^6(k^2-1).$$

Since K is a constant, $dk/dR=-2(k+1)/R$; substituting this derivative in the expression for $dV/dR=0$, we get $dk/dR=-3(k^2-1)/Rk=-2(k+1)/R$. Hence $k=3$, and L = 3R.

Also solved by *Paul Lewis, Tahlequah, Okla.; Louis R. Chase, Newport, R. I.; W. E. Buker, Leetsdale, Pa.; J. F. Howard, San Antonio, Texas;* and by *Sudler Bamberger, Harrisburg, Pa.*

PROBLEMS FOR SOLUTION

1145. *Proposed by Peter Drohan, Toronto, Ont.*

Find the formula for the sum of the nth powers of the coefficients in $(a+b)^n$, where n is any positive integer.

1146. *Proposed by Lu Chin-Shih, Soochow Univ., Soochow, China.*

If a line is parallel to one side of a triangle, it divides the other two sides into proportional segments. Prove the case when the sides are divided into irrational segments by means of synthetic method. Do not use the indirect method, or involve any idea of limits.

1147. *Proposed by W. E. Buker, Leetsdale, Pa.*

Show that the sum of the 7th and 5th powers of the first n whole numbers is double the square of the sum of their cubes.

1148. *Proposed by Walter Carnahan, Indianapolis, Ind.*

In Altschiller-Court's College, page 66, the following statement is given, "A triangle may have two equal external angle bisectors and not be isosceles." Give a figure to illustrate and prove.

1149. *Proposed by R. T. McGregor, Elk Grove, Cal.*

A number of three digits in the scale of 7 when expressed in the scale of 9 has its digits reversed. Find the number.

1150. *Proposed by J. K. Thornton, Fillmore, Cal.*

Three ladies go shopping. A said to B and C, give me half of your money and I can just buy that chicken; B said to A and C, give me one-third of your money and I can just buy the chicken; C said to A and B, I can do better than that, give me one-fourth of your money and I can buy it. How much money did each lady have, if the chicken was priced at $1?

DIVIDENDS ON HEALTH ASSETS.

What returns can be expected as a result of health training in our schools? Of course the dividends never can be computed with quite the precision of a financial investment. But, like an investment, they will depend on what the health assets are in the beginning and how well they are conserved and increased. Perhaps the first thing to be done by any persons interested in the problem is to make an inventory of their own school and community.

A ready way to take such an inventory is to use a sheet prepared for this purpose by the National Tuberculosis Association, 370 Seventh Avenue, New York, which is available through any of the state and local tuberculosis associations engaged in the country-wide Christmas seal sale. Part of the money raised each year is used to provide such means as these for the promotion of good health among children. To make the inventory, the teacher, or other interested person, checks certain questions "Yes" or "No."

These questions pertain to the schoolroom, the community, and the pupils. They include such pertinent and revealing interrogatories as "Is the Ventilation of the schoolroom good? (a) Windows open whenever possible, (b) 68 degrees is a desirable temperature." In relation to the community, such questions are propounded as: "Is there medical inspection of the children?" and "Is there a school nurse?" In following the inventory through to the pupils themselves, teachers are asked to answer these queries, among others: "How many sleep long hours with windows open?" and "How many look like healthy, happy children?"

In addition to the questions comprising the inventory, a "progress chart" may be kept. The good marks are added in the asset column, showing the increase in the health balance from time to time.

HOW TO STUDY GEOMETRY.

By ETHEL M. HENDRICK,
University of Southern California.

The large number of failures and withdrawals of students from plane geometry classes[1] shows that there is need for an improved study technique. With one principal exception[2], most of the material on study habits is of a general nature and does not apply to particular subjects. This investigation was an attempt to gather material from direct sources which would be of value to students in the study of geometry.

The general procedure followed in this investigation was of the "job analysis" type, as described by C. C. Crawford in "The Technique of Research in Education"[3]. The first step was to discover the parts of the task which presented difficulties for the student. This list of difficulties was collected from discussions with students and teachers, from printed material on the subject, and from personal observation. The interviews with the teachers gave better results than those with the students, because the latter were unable to analyze their deficiencies. The difficulties were then reclassified under major topics.

The methods were collected through interviews with thirty teachers of geometry in high schools in and near Los Angeles. Specific questions were asked as to what methods they could suggest for meeting each difficulty listed. Notes were taken during the interviews. This material was reorganized and supplemented by other material, from all available sources. No attempt was made to evaluate the material and all of the suggested methods, which seemed pertinent, were included. The following outline presents a brief summary of the methods of study as collected and organized.

I. HOW TO LEARN THE TERMINOLOGY OR TECHNICAL VOCABULARY.

1. Learn the vocabulary as you meet it in your daily work.
2. Correlate geometric terms with the ordinary vocabulary by translating old expressions, such as "corners fit," into geometric terms.
3. Use derivations to help learn the spelling of terms.

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[1] *Table of Failures and Withdrawals*, School Review, June, 1918, Vol. XXI, p. 415.
[2] Claude C. Crawford, *Studying the Major Subjects*, Published by C. C. Crawford, University of Southern California, Los Angeles, 1930.
[3] C. C. Crawford, *The Technique of Research in Education*, Chap. VIII. Published by The University of Southern California, Los Angeles, 1930. Chapter VIII, "Job Analysis."

4. Break words up into parts; "tri" and "quad" are met in many combinations.
5. Connect symbols with the geometric concepts which they represent.
6. Translate geometric relations into pictures or drawings.
7. Form the habit of constructing a mental image of new relations.
8. Review axioms as used in arithmetic and algebra.
9. In learning theorems, separate the theorem into the hypothesis and conclusion, and learn each division as a separate thought.
10. Learn the fundamental assumptions as foundation structure.
11. Associate corollaries with the parent theorem.
12. Memorize each theorem and corollary so well that ready recall is assured.
13. Learn all definitions and theorems without omissions.
14. Develop a geometrical vocabulary by frequent use of terms.

II. How to Learn the Proofs of Theorems.

1. Memorize the exact theorem and learn its meaning.
2. Drill on picking out the hypotheses and conclusions of theorems.
3. Draw the figure to meet the conditions of the hypothesis.
4. Develop a definite form and order of presentation.
5. State the hypothesis and conclusion in terms of the figure rather than in general terms.
6. Learn to be a geometrical explorer and discover facts for yourself, rather than memorizing a ready-made proof.
7. Plan your method of attack before drawing auxiliary lines.
8. Use the conclusion as the basis for starting a plan of proof.
9. Study the line of argument presented in the text but do not memorize the steps.
10. Learn how to translate a plan of proof into a form of logical reasoning.
11. Learn the various methods of proof and the limitations of each.
12. Omit abbreviations in the first half dozen proofs to start the habit of making full and complete statements.
13. Study orally at home. Pin a figure on the wall and explain a proof to the "furniture."
14. Present demonstrations as a lawyer arguing a case.
15. Modify the form of proof to meet the teacher's requirements.

III. How to Solve Original Exercises.

1. Emphasize a correct interpretation of the proposition.
2. In propositions involving constructions, make a rough sketch and analyze the relations pictured.
3. Review the theorems preceding the exercises.
4. Avoid re-proving theorems in original exercises.
5. Use a forward method of attack on very simple problems.
6. Reread a problem after making the construction, to verify your interpretation of relations.
7. Begin your analysis with questions; what do I need to prove?, etc.
8. Make a card catalogue of all the known facts.
9. Make a mental review of possible methods of establishing the desired relationship, equal segments, angles, triangles, etc.
10. Use the teacher's method as a help in developing your own technique of proof.
11. Study examples of analysis applied to original exercises.
12. Learn how to transform an analysis into a synthetic form of proof.
13. Develop the ability to analyze problems by repeated practice.
14. Designate by marks, the equal parts in a figure.
15. Try to match equal parts as a method of forming relationships.

16. Review the fundamental processes of algebra and arithmetic as an aid in numerical application.
17. Choose geometric proofs rather than algebraic solutions where both are possible.
18. Attempt a solution before asking help.
19. Study your individual method of proof and try to improve it.

IV. How to Make the Best Adjustment As to the Use of Memory and Thinking.

1. Cultivate a memory of meanings rather than a memory of lists of words.
2. Memorize definitions, axioms, assumptions, and theorems to the point of ready recall.
3. Develop proofs for theorems and original exercises by a reasoning process.
4. Develop the ability to think through a proof, rather than reproduce the proof of another.
5. Use similarities and differences of theorems as a means of remembering them.
6. Remember the converse of a theorem by the "so that" clause.
7. Avoid remembering the lettering on a figure.
8. Remember certain tricks of construction as handles to use in recalling proofs.
9. Learn the exact meaning of a symbol used in a formula.
10. Underestimate rather than overestimate your ability to remember.
11. Store the proofs in your mind in a logical sequence.

V. How to Make the Best Use of Geometric Figures in Proofs.

1. Own your instruments for construction work.
2. Separate drawing operations into elements.
3. Cultivate accuracy in constructions.
4. Use a general figure, specific cases often lead to conclusions which are not true for *all* figures of that type.
5. Make use of dotted lines to distinguish auxiliary construction from the original construction.
6. Use colored crayons to show overlapping or complicated figures.
7. Develop a uniform system of lettering.
8. Use cardboard figures and folded paper as illustrations.
9. Use geometric constructions as a basis for art designs.
10. Use geometric figures in constructing graphic illustrations.
11. Use geometric figures as the basis for a composition in your English class.

VI. How to Use Concrete Materials in Geometry.

1. Study the surveyor's instruments and learn the principles on which they are based.
2. Practice elementary surveying by using equal triangles to measure distances.
3. Learn the applications of geometry in navigation.
4. Construct geometric instruments—a plumb line, a quadrant.
5. Include geometric subjects in your reading program.
6. Learn the different uses for a carpenter's square.
7. Learn how to draw maps to a scale.
8. Play chess and checkers to develop the ability to "plan ahead of the game."
9. Observe geometrical designs in nature.
10. Learn to solve geometric exercises and puzzles as a leisure pursuit.

VII. How to Profit from Blackboard Work.

1. Try to profit from the demonstration of the teacher by giving undivided attention.

2. Adopt a critical attitude toward blackboard work.
3. Practice soon after aid is given in the class-room.
4. Use your own demonstrations as a practice period in public speaking and oral English.
5. Use your blackboard illustration as the focal point of your demonstration.
6. Cultivate an ease of manner by exclusive interest in your proof.
7. Don't sacrifice explanations of the teacher or classmates by taking notes.
8. Try to realize your errors in the exposition of another.
9. Expect to be asked to finish a proof at any time.
10. Practice constructions at the blackboard at all opportunities.
11. Develop your skill by helping your classmate with his constructions.
12. Write enough facts on the blackboard to make your solution clear to others.

VIII. How to Verify Conclusions.

1. Check your figure with your proposition to verify the interpretation of terms.
2. Check for omissions in the figure.
3. Check the steps of analysis with the list of possible methods of solution.
4. Check the use made of auxiliary lines with their mode of construction.
5. After one solution is reached, reread the problem to check the number of solutions required.
6. Compare the last statement of the proof with the conclusion of the proposition.
7. Have someone else check your proof.
8. If there is doubt concerning the meaning of a proposition, read it aloud.
9. In numerical or algebraic solutions, use approximations as a check.
10. If algebraic equations are involved, substitute the result in the original problem.
11. If solving the values of angles, check by the theorems: "The sum of the interior angles (of a triangle or polygon)."
12. Check loci problems for all possible solutions.
13. Verify the statement of a formula.
14. Form the habit of checking for fallacies of reasoning.
15. Use "true-false" questions to check up vague points.

IX. How to Make Proofs Function in Later Work.

1. Memorize thoroughly definitions, theorems, axioms.
2. In learning a new theorem, review the other theorems involved in the proof.
3. Solve some exercises applying each group of theorems.
4. Concentrate on your weak points.
5. Summarize facts which can be used to establish a desired outcome.
6. Emphasize important theorems in review work.
7. Use several different methods for review purposes—reconstruction of proofs mentally, matching figures and proofs, etc.

X. How to Generalize the Understanding of Proofs.

1. Build a "family tree" for a theorem.
2. Visualize a corollary as a specific application of a general case.
3. Prove a theorem by several methods.
4. Vary the shape, size and lettering on a figure.
5. Test your powers of deduction with a distorted figure.
6. Eliminate the use of special cases.

7. Study the process of generalization (as applied to the interior angles of *any* polygon).
8. Use practical applications to enlarge the meaning of theorems.
9. Solve problems to test the power of application.
10. Become acquainted with the meaning of non-Euclidean geometry.
11. Develop relations between different divisions of mathematics.

XI. How to Study Particular Divisions of Geometry.

1. Rectilinear figures.
   a. Learn *all* definitions.
   b. Learn the exact process of superposition.
   c. Learn the history of some of the theorems.
   d. Learn how the navigator "doubles the angle on the bow."
   e. Correlate the study of rectilinear figures with the other courses of high-school; art, physics, history, shop-work.
2. The circle.
   a. Connect the relations of arcs, chords, and central angles.
   b. Discriminate between "inscribed in" and "intercepted by."
   c. Group theorems relating to the measurement of angles.
   d. Apply the knowledge of the circle in graphs, Parcel Post zones, latitude and longitude, wheels, gas and electric meters, art and landscape designs.
3. Loci problems.
   a. Organize a "treasure hunt."
   b. Solve independently the different conditions of a loci problem.
   c. Check for all possible solutions.
   d. Apply the principles in the world about you.
4. Proportion and similarity.
   a. Use corresponding sides together.
   b. Learn how to transform proportions.
   c. Learn how to draw figures to a scale.
   d. Correlate the study of ratio and proportion with the home-economics courses; budgets, increases and decreases in recipes, adjusting patterns to different figures, all use ratio and proportion.
5. Polygons and their areas.
   a. Learn how to derive formulae as well as how to use them.
   b. Break up irregular polygons into familiar shapes.
   c. Study the ancient formulae for areas and compare with the modern statements.
   d. Study areas with a practical objective such as their use in real-estate subdivisions, surveying, estimating costs in constructions of bridges and buildings, paving estimates, etc.

TEMPEL'S SECOND COMET FOUND.

Tempel's second comet, last seen on its visit in the summer of 1925, has again returned to the neighborhood of the earth. Prof. George Van Biesbroeck, of the Yerkes Observatory, picked it up on the evening of Sunday, Sept. 21. The comet was within approximately the diameter of the full moon of the place predicted for it by Dr. A. C. D. Crommelin, famous English authority on cometary orbits. Dr. Crommelin made his prediction about a year ago.

Tempel was a European astronomer who first discovered this comet in 1873. Since then it has been observed on seven returns, including the present one, and it comes back once in about five and a fifth years. It never becomes bright enough to be seen with the naked eye. At present it is of about the twelfth magnitude, visible only through large telescopes.

A STUDY OF SOME DIFFRACTION PHENOMENA.

By C. W. BATDORF,
San Mateo Union High School, San Mateo, Calif.

Some high school physics textbooks omit the subject of diffraction, but so many common phenomena are due to diffraction effects, that it seems to the writer worth while to lead our physics students into the way of observing and understanding them. It requires but a short time, and a small amount of very simple apparatus, to show students a number of cases of light "bending round a corner," and I have always found them interested.

One of the simplest means is to have the students view an incandescent filament, or, better, a candle flame, through the meshes of thin cotton cloth, in a darkened room. Another piece of apparatus easily supplied to each member of a class is a sheet of "tin" about three inches square, with a single cut made by tin snips, extending about three quarters of the way across the sheet. Often the cut is wide enough to give an excellent view of the diffraction interference bands, when looking at a candle flame, or at sky light. Or, the cut can be held apart slightly at the top, to form a tapering slit, which will yield a pattern quite as good as that photographed in Edser's "Light for Students," 1902 edition, P. 437, Fig. 233. By slightly rotating the metal plate in the vertical plane, about the slit as an axis, viewing the source through the changing width, the pattern can be varied over a wide range. If we look through the vertical slit between two fingers, with the hand held at a little distance from the eye, we may see diffraction bands at the edges of the fingers. If we hold the fingers close to the eye, we may see excellent diffraction interference bands on each side of each vertical strand of an incandescent filament. If we hold the fingers in a horizontal position, and look through the finger-slit at a Mazda lamp suspended vertically at the level of the eye, we get an excellent view of light bending round a corner. And this view may be greatly improved by holding one straightedge at arm's length in one hand, and another straightedge at half the distance in the other hand, both in a horizontal position, and bringing the nearer straightedge

downward until it just cuts off the view of the upper edge of the farther straightedge. The beams of light will then be bent over the lower edge of the nearer straightedge, and can be seen spread out on the farther straightedge as a background. The relative distances here suggested can be varied with good results, and by bringing the nearer straightedge still farther down we can determine how far the light is diffracted from the straight line. An exceptionally large number of diffraction bands, and an exceptionally clear view of them, may be obtained by holding the straightedge as near the eye as possible, right against the bridge of the nose, and looking at the lowest, horizontal strand of a Mazda filament, the rest of the strands being concealed from view behind the ruler. The distance should be about three feet. Many other available experiments, including descriptions of gratings, are given in physics textbooks.

Anyone may see excellent diffraction effects by looking at the electric lights through the composition windows of the motor bus. Very extensive diffraction patterns are formed, due, likely, to the surfacing, rather than to the texture, of the material.

But a common phenomenon, well calculated to excite the wonder of any inquiring mind, is the streamers, or beams of light, which seem to extend outward and toward the observer, from any bright light, such as a distant headlight, a street lamp, or a bright star. Sometimes it is like looking into a cone of beams, toward the apex; and sometimes there is a long bright beam on the upper side of the source, sometimes on the lower side, and sometimes both above and below. Sometimes the wide end, nearest the eye, spreads out in curved lines; sometimes we may observe a net-like, or web-like, cone of beams, and often, when viewing the early morning sunlight at the proper angle, (while lying abed!), we may see intricate patterns of rich spectral colors. Let us examine in detail some of these phenomena, and try to account for them.

If we look at a distant street light with the head thrown well back, we can see a long beam on the upper side of the light. If we lower the head, and turn the eyes

upward to see the light, the beam will appear on the lower side. If we squint properly we can see both beams at once. Now, using only one eye, so adjusted that both beams appear, if we hold a straightedge in a horizontal position a foot or two in front of the eye, and move it from below upward until the edge just cuts off the lower side of the light, the upper beam will be suddenly cut off, and the lower beam will continue to shine as if coming right through the straightedge. If we move the straightedge from above downward until it just cuts off the upper edge of the source, the lower beam will be cut off, and the upper beam will continue to shine through the straightedge. This experiment furnishes direct and interesting evidence that the image on the retina is inverted. It is evidence that appeals to students, but requires a bit of ingenious thinking for its proper interpretation.

This long bright beam on the upper side of a small bright source of light is brought into view when the lower eyelid is drawn up to a position opposite the lower edge of the pupil, so that the light from the lower edge of the source bends over the lower lid as it enters the pupil. The direction of this bent beam is such that the refracting power of the eye lens system is insufficient to cause the beam to impinge upon the upper side of the retina; it impinges upon the lower side of the retina, and hence looks to us as if it were coming from the upper side of the source of light. Likewise, the beam which we see on the lower side of the source is caused by the light bending over the upper eyelid, just opposite the upper side of the pupil. It impinges upon the upper side of the retina, and that is why we see it on the lower side of the light source.

That the two bright beams are caused by light bending over the eyelids can be verified quite easily. If the head is turned in a vertical plane, the beams follow the direction of turning. If the fingers are used to rotate the eyelids in the vertical plane, the motion of the beams is the same as when the head is turned.

The spreading out, and curving, of the nearer end of

the diffraction beams, is due to the moisture on the surface of the eye. If there be a tear drop on the eye, the curvature of the beams may be considerable. If facing a cold wind, so that the tear glands become very active, the diffraction beams become extensively refracted by the water present in the eye, interfering seriously with vision, and distorting the diffraction patterns beyond recognition.

The small cone of rays extending uniformly outward from a bright light at night, is caused by diffraction at the edge of the iris. These beams are irregular streamers, because the texture of the pupil boundary of the iris is irregular. Furthermore, by gazing steadily at the image of the iris in a mirror, we can see that the iris is constantly dilating and contracting, due to the constant relaxing and contracting of the muscles concerned. This accounts for the ever changing position of the beams in the diffraction cone, no matter how hard we try to keep the eye still. This effect is more noticeable when the source is not too distant; fifty feet or so. (Part of this motion is sometimes due to the action of the accommodation muscles, but not all of it).

We may learn something of the close connection between the two eyes by properly viewing a diffraction pattern. Obtain a view of the large beams from a distant street light, using the right eye, the left eye being shaded from the source. Now squint slightly with the right eye, and observe the resulting motion of the diffraction pattern. Next, without changing the adjustment, try to hold the right eye perfectly still, and close the left eye. The motion of the diffraction beams will show that it is impossible to hold the muscles of the right eye steady while blinking with the left eye.

Countless other diffraction phenomena are easily observable, and it is hoped that these few paragraphs will lead the reader to recognize many of them, and not be puzzled to account for their appearance. All eyes are not exactly alike, but the earnest experimenter will persist until he finds the positions in which interesting results can be obtained.

COST OF TEXTBOOKS.

The Statistical Summary of Education, 1927-28, recently published by the Federal Office of Education, contains one section of valuable data that had not previously been collected since 1915. This has to do with expenditures for textbooks. The Commissioner of Education has ascertained that only 1 63/100 per cent of the expenditures for public schools are represented by the net cost of public-school textbooks. This figure is much smaller than that for 1913, when 2 73/100 per cent of the expenditure for public schools was represented by the net cost of textbooks. He also found that in 1928 the net cost of public-school textbooks, elementary and high school, was $1.351 per child enrolled.

For those with a taste for statistics there is a wealth of data in the Summary referred to. It is shown, for instance, that the total net cost of books for elementary schools, public and private, in the United States and Philippine Islands amounts to nearly $23,000,000, while the corresponding cost for high-school textbooks is a bit over $16,000,000. Thus the net cost of school textbooks produced in the United States amounts in grand total to about $39,000,000.

Of course this $39,000,000 for school textbooks seems small when we compare it with some of our other expenditures. According to the Statistical Abstract of the United States for 1929, the manufacture of chewing gum is a business half as large again, and that of making confectionery ten times as large. Even in these days of small, plain hats for the ladies' millinery costs five times as much as school textbooks. Soap costs seven times as much; and when we come to the figures for cigars and cigarettes, we find that our tribute to Lady Nicotine is about twenty-five times that to Minerva, if the latter lady is fairly represented by textbooks for the schools. Even for the lowly match which blazes for an instant as we light our cigarette we surrender more millions than we do for the arithmetics, geographies, and other textbooks with which we equip all the elementary grades of all our public and private schools. Truly we ought to be able to afford the best textbooks.

TO FILL A BAROMETER TUBE.

I wish to take exception to the statement of the method of Mr. M. T. Skilling in his article entitled "Background and Foreground of General Science," printed on page 500 of the May issue. He says to fill a barometer tube with mercury with a medicine dropper. My experience with a medicine dropper has been that very little mercury can be picked up with a medicine dropper since the rubber bulb will collapse due to the weight of the mercury. Consequently, in order to fill a barometer tube with mercury would require quite a lengthy process as only a few drops could be picked up at a time with it. A much better method is to put the mercury in a beaker or a mortar with a lip. Grasp the barometer tube at the top so that the thumb and forefinger form a natural cup. The mercury is then slowly poured into the barometer tube. This has a distinct beneficial effect on the class as their interest is caught and held by the skill in handling an unusual liquid without any waste of the liquid or time in doing. They also admire and appreciate such skill on the part of the teacher.—D. G. Vequist, Benton High School, St. Joseph, Mo.

BOOKS RECEIVED.

Carpentry Mathematics, Part I by J. Douglas Wilson, Head of Building Trades Department, Frank Wiggins Trade School, Los Angeles, California and Clell M. Rogers, Related Mathematics Instructor, Venice High School, Venice, California. First Edition. Cloth. Pages ix+232. 14x20.5 cm. 1930. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price $1.80.

Strasburger's Text-Book of Botany rewritten by Dr. Hans Fitting, Professor in the University of Bonn, Dr. Ludwig Jost, Professor in the University of Heidelberg, Dr. Heinrich Schenck, Professor in the Technical Academy of Darmstadt and Dr. George Karsten, Professor in the University of Halle, Saale. Fifth English Edition. Revised with the Fourteenth German Edition by W. H. Lang, Barker Professor of Cryptogamic Botany in the University of Manchester. 833 illustrations, in part colored. Cloth. Pages xi+799. 14x22 cm. 1921. The Macmillan Company, 60 Fifth Avenue, New York. Price $9.00.

The Stars Through Magic Casements edited by Julia Williamson and illustrated by Edna M. Reindel. Cloth. Pages xxi+239. 13x19 cm. 1930. D. Appleton and Company, 35 West 32nd Street, New York.

Directed Study Guides for Stevenson's Treasure Island by Alma Leonhardy and Grace W. Hogoboom. Paper. 68 Pages. 21x28 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price 48 cents.

Diagnostic and Remedial Teaching in Arithmetic by Leo J. Brueckner, Professor of Elementary Education, University of Minnesota, Formerly Director of Instructional Research, Minneapolis Public Schools. Cloth. Pages ix+341. 20x14.5 cm. 1930. The John C. Winston Company, Winston Building, 1006-1016 Arch Street, Philadelphia, Pa. Price $2.00.

Workbook to Accompany Introduction to Science by Otis William Caldwell, Professor of Education and Director of Institute of School Experimentation of Teachers College, Columbia University and Francis Day Curtis, Associate Professor of Secondary Education and of the Teaching of Biology and General Science, University of Michigan, and Head of the Department of General Science and Biology in University High School. Paper. Pages x+245. 18.5x26.5 cm. 1930. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price 72 cents.

Workbook in Plane Geometry by Hugh D. MacIntyre, Instructor in Mathematics at the Charles E. Gorton High School, Yonkers, New York. Paper. Pages v+121. 20x26 cm. 1930. World Book Company, Yonkers-on-Hudson, New York. Price 80 cents.

Analytic Geometry by Arthur M. Harding, Professor of Mathematics, University of Arkansas and George W. Mullins, Professor of Mathematics, Barnard College, Columbia University. Revised edition. Cloth. Pages x+316. 12.5x19 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.50.

Modern Algebra, Intermediate Course by Raleigh Schorling, Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan, John R Clark, The Lincoln School, Teachers College, Columbia University and Selma A. Lindell, The University High School, University of Michigan. Cloth. Pages vi+346. 13x18.5 cm. 1929. World Book Company, Yonkers-on-Hudson, New York. Price $1.36.

What is Education? by L. A. Sherman, University of Nebraska. Paper. 40 pages. 12.5x18 cm. 1930. Henry C. Frick, Educational Commission, 465 Union Trust Building, Pittsburgh, Pa.

Algebra Charts by Edgar Dehn, Columbia University. Columbia Press, 509 Fifth Ave., New York. Set of Six Charts, $1.00; single charts with directions, 15 cents.

INTERNATIONAL ASTRONOMICAL CONGRESS TO FOLLOW 1932 SOLAR ECLIPSE.

American astronomers will be host to the astronomers of the world in 1932, just following the total solar eclipse which will be visible in New England on August 31 of that year.

The scheduling of a meeting of the fourth congress of the International Astronomical Union at Harvard during the week following the 1932 eclipse was announced by Dr. Harlow Shapley, director of the Harvard College Observatory.

Thus scientists who study the sky will have a dual attraction drawing them to America year after next, and more than a hundred foreign delegates from twenty countries are expected. The astronomer royal of Great Britain, Sir F. W. Dyson, is president of the International Astronomical Union, and the last meeting of the union was held at Leyden, Holland, in 1928.

As befits the universal scope of their science, the astronomers of the world carry on much international research under the auspices of the International Astronomical Union. The international programs are administered through the agency of thirty international commissions, which deal with solar phenomena, variable stars, time determination, and numerous large cooperative researches in stars and nebulae.—*Science Service.*

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A Laboratory Manual of General Chemistry by William J. Hale, Director, Organic Chemical Research, Dow Chemical Company and revised by William G. Smeaton, Professor of General and Physical Chemistry, University of Michigan. Cloth. Pages x+530. 12.5x19 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.50.

Everyday Physics by Carleton John Lynde, Professor of Physics, Teachers College, Columbia University, New York. Cloth. Pages xiii+577. 12.5x19 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.80.

Laboratory Studies, Demonstrations, and Problems in Biology by Nathan Harvey Kingsley, Late Director of the Departmen of Biology, Lincoln High School, Milwaukee, Wisconsin and arranged and edited by Edward J. Menge, Director of the Department of Animal Biology, Marquette University, Milwaukee, Wisconsin. Paper. 208 pages. 21x28 cm. 1930. The Bruce Publishing Company, 524-544 N. Milwaukee St., Milwaukee, Wisconsin. Price $1.28.

The Scientific Fundamentals of Gravity Concentration by Josef Finkey, Professor of Ore Dressing of the School of Mines, Sopron, Hungary, translated into German from the Hungarian by Johann Pocsubay, Assistant Professor, School of Mines, Sopron, Hungary, translated from the German by C. O. Anderson and M. H. Griffitts. Bulletin, School of Mines and Metallurgy, University of Missouri, Rolla, Missouri. Price $1.00.

BOOK REVIEWS.

Calculus, by Egbert J Miles, Associate Professor of Mathematics in Yale University, and James S. Mikesh, Master in Mathematics in the Lawrenceville School. Pages xiii+638. 16x21.5 cm. Cloth. 1930. McGraw-Hill Book Company, 370 Seventh Avenue, New York. Price $3.75.

The authors of this Calculus have made a special effort to write a text which can be read by a student with understanding and interest. They give much attention to the development of fundamental ideas and processes. Thus, more than fifty pages are devoted to the notions of limits. The notion of rate of change, which is the unifying principle of the subject, is set forth in a chapter of more than twenty pages. In order to have the student feel that he is treading on familiar ground during the presentation of his notion, ordinary algebraic symbolism is employed. Throughout the text one finds that emphasis has been placed on principles rather than on manipulation of symbols.

The problems of the integral calculus are also treated from the standpoint of rate of change. In the first course the integral is defined as an inverse derivative. We thus find the notation $\int_a^b f(x)$ instead of the familiar $\int_a^b f(x)\,dx$. J. M. Kinney.

Projective Geometry, by John Wesley Young, Professor of Mathematics, Dartmouth College. Pages ix+185. 15.5x19.5 cm. 1930. The Open Court Publishing Company, 337 East Chicago Avenue, Chicago, Illinois. Price $2.00.

This is the fourth Carus Mathematical Monograph. The publication of this monograph by the Mathematical Association of America, as well as others of the series which have been and are to be published, is made possible by a gift of Mrs. Mary Hegeler Carus.

The purpose of this monograph is to give, not only teachers and students specializing in mathematics but also workers in other fields who have had a moderate training in elementary mathematics, an

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exposition of Projective Geometry. The author develops the subject through the first five chapters by synthetic methods. The treatment is intuitional rather than postulational. In the sixth chapter he shows how metric properties are related to projective properties. In the remaining three chapters he discusses groups of projective transformations, the algebra of points, analytic methods, groups, and geometries. J. M. Kinney.

The Aryabhatiya of Aryabhata. Translated with notes by Walter Eugene Clark, Professor of Sanskrit in Harvard University. Cloth. Pages xxix+90. 13x19.5 cm. 1930. The University of Chicago Press, Chicago, Illinois. Price $2.50.

The Aryabhatiya is the earliest preserved Hindu text on mathematics and astronomy It was written by Aryabhata who was born 476 A.D. It consists of four chapters. The first deals with Aryabhata's system of astronomy; the second, with mathematics; the third, with the reckoning of time; the fourth, with the "The Sphere."

Professor Clark states that this translation with its brief notes makes no pretense at completeness. He hopes that it will attract the attention of Indian scholars and induce them to make available more adequate manuscript material. J. M. Kinney.

Trigonometry, by A. R. Crathorne and E. B. Lytle, University of Illinois. Pages ix+199+95. 13.5x20 cm. 1930. Henry Holt and Company, New York.

This is a flexible text in trigonometry which may be used for course of various lengths, two, three, or perhaps, four hours. The authors give an outline of a two-hour course in which they mention the material that may be included and the amount of time that should be given to each topic.

Special attention has been given approximate computation. There are many practical problems. The exercises are made up of two complete sets, one with answers, the other without answers. Besides the usual topics we find a chapter on Complex Numbers and Hyperbolic Functions, two chapters on Spherical Triangles, and a chapter on Terrestial and Celestial triangles. J. M. Kinney.

Mathematical Introduction to Economics by Griffith C. Evans, Professor of Pure Mathematics, Rice Institute. First Edition Cloth. Pages xi+173. 14x23.5 cm. 1930. McGraw-Hill Book Company, Inc., New York, 370 Seventh Avenue. Price $3.00.

This book aims, in the words of the author, "to give a short unified account of a sequence of economic problems by means of a few rather simple mathematical methods." It is primarily a text for college students who have had the elements of calculus and it is well supplied with exercises. It is a very enlightening volume for any economist who has never learned to appreciate the usefulness of mathematics, especially the calculus, in his theories.

In order to apply mathematics to the economic problems considered, it is of course necessary for the author to make certain assumptions as to production, supply, demand, etc. Each set of assumptions approximately defines a certain class of economic situations that may exist in actual business. It is interesting to note the various results under different assumptions. Such topics as "Equilibrium under Monopoly of Production," "Price Fixing," "Competition and Cooperation," and many others are thus treated and the economic result obtainable under certain initial economic conditions is predicted on the basis of the solution of a mathematical equation.

The discussion of "Economic Theory in General" in connection with "The Mathematical Method" in Chapter X exhibits a very wholesome philosophy in relation to the extension of mathematics to wider fields of application.

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Lecture Experiments in Optics, by B. K Johnson. Pages 112. (London: Edward Arnold & Co., 1930.) 8s. 6d.

This little book will be welcomed by all who have to prepare experimental demonstrations to accompany lectures on optics. It does not pretend to discuss the theory involved in the experiments, but it does try to give just those helpful hints which the demonstrator needs in setting up his apparatus to explain the theory by means of a practical demonstration. Experienced teachers will find many of their old friends among the experiments selected, but probably every teacher will find suggestions for doing certain difficult demonstrations which he has thus far not been able to do satisfactorily. The author has had years of experience as a demonstrator in the Imperial College of Science and Technology (London).

The book contains ninety cuts, mostly diagrams showing clearly the essential features of the arrangement of the apparatus. After each experiment there is given a brief list of the equipment required. The author recommends as a source of light the 5 to 10-ampere carbon-arc lamp (and occasionally the 500-c.p. "Pointolite" lamp). For an optical bench he uses the solid triangular bar one meter long, which is the standard equipment of the Zeiss optical works and which has been adopted by many German schools and universities. On this as a basis he has built up his equipment, much of it very simple and such as would be found in any well equipped laboratory or could be made in the laboratory workshop. Over eighty experiments are described, some of them very simple, on the usual topics in optics covered in a general course in physics.

Not since the time of Tyndall have we seen in English so useful a book for the demonstrator of optical experiments. It would undoubtedly be a great help to those who are starting their careers as teachers of physics if we could have a series of such books covering the other main divisions of physics.

N. Henry Black.

General Chemistry, by Harry N. Holmes, Professor of Chemistry, in Oberlin College. Revised Edition. Pages x+654. 15.5x22x3 cm. Illustrated (over 100 new illustrations in the revised edition) new type resistant cloth binding. 1930. Macmillan.

Here is a real revision of the type which makes the energetic chemistry teacher glad he is alive in a period when chemistry is growing so rapidly, but which makes the indolent teacher despair of ever catching up with his subject.

We find the sub atomic structure theory appearing in the second chapter, reappearing in the chapter on Valence (Chap. VII) and again in the chapters on Ionization (XVI) and on balancing Oxidation-Reduction equations, and finally in a chapter on The Structure of the Atom (XXI). Thus this new viewpoint is introduced very early and applied as occasion requires. It may be added that the theory is given as a tentative one which is still in process of development.

The treatment of Ionization is followed by supplemental material showing the action of liquid ammonia, fused salts and Phosgene in dissociating compounds which may be regarded as acids, bases and salts in those systems.

As further evidence of real revision we have a chapter on Photo Chemistry with the most recent conclusions of Baly and others in regard to the mechanism of photosynthesis.

Lest the reader should conclude from our illustrations that the book is written above the level of the college freshman we should hasten to add that its style is most human and interesting.

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A Laboratory Manual of General Chemistry, by William J. Hale, Director, Organic Chemical Research, Dow Chemical Co., revised by William G. Smeaton, Professor of General and Physical Chemistry, University of Michigan. Pages x+530. 14x19x2.5 cm. With diagrams, solubility curves, etc. Cloth. 1930. Macmillan.

This revised edition of Hale's Laboratory Manual brings it up to date, adds some new material, especially on analytical procedure, and gives some preliminary material on organic chemistry.

The merit of the work is proven by its eleven reprintings. As a rule the right hand page is left blank for note writing and it is usually numbered at the left to facilitate an orderly building of the notes to agree with the numbered paragraphs of procedure.

The instructions are brief but clear and are such as a college student should be capable of grasping.

F. B. W.

A Second Course in Algebra, by Harry C. Barber, head of the Mathematics Department in Phillips Exeter Academy, Exeter, N. H. Cloth. Pages xvii+505. 1930. Houghton Mifflin Company, Chicago.

This second course in algebra is intended to follow any good first course in algebra. Sufficient material is provided for a full year's work, but it is so arranged that it may be used for a course lasting only one-half year. There are several distinctive features of the text. Among them are:

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3. The function concept, through the use of the words *number relations*, is emphasized throughout the text, and especially in chapter viii on *Dependence*.

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G. E. Hawkins.

Junior Mathematics, by George Drayton Strayer, Professor of Education, Columbia University and Clifford Brewster Upton, Professor of Mathematics, Columbia University. Book One, pages vi+266+xix; Book Two, pages vi+282+xxii; *Modern Algebra*, pages vi+314+xxxii. 1930. American Book Company, New York.

The Strayer-Upton *Junior Mathematics* is a series of three books intended for a complete course in the junior high school mathematics. *Book One* introduces the pupil to the fundamental processes of algebra and basic concepts of intuitive geometry. Both of these sets of new ideas are directly associated with arithmetical operations and manipulations. *Book Two* presents the pupil with manifold opportunities for the utilization and application of both the algebraic and geometric notions which he acquired the first year. *Modern Algebra* is a comprehensive treatment of the fundamental concepts and processes of elementary algebra.

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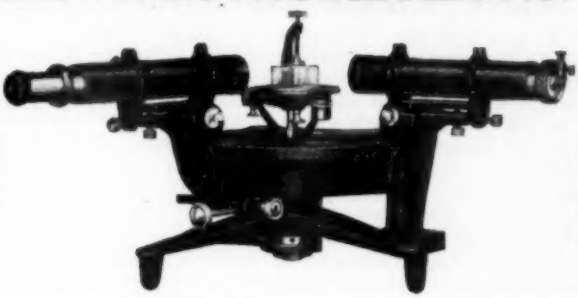

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J. S. Georges.

The Theory of the Potential by W. D. MacMillan, Professor of Astronomy, The University of Chicago. Cloth. Pages xiii + 469. 1930. McGraw-Hill Book Company, New York. Price, $5.00.

In the mathematical treatment of various branches of physics, as for example, gravitational and magnetic attraction, electrostatics, the steady flow of electricity and heat, hydrodynamics, etc., the partial differential equations $\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y}=0$ and $\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}=$ are of very fundamental importance. Furthermore, the first of these equations lies at the core of that branch of mathematics known as the Theory of Functions of a Complex Variable. These equations are called Laplace's partial differential equations in two and three variables respectively, and it is with the properties of the functions that satisfy these equations that Potential Theory is mainly concerned.

MacMillan's *The Theory of the Potential* presents a splendid and elementary introduction to this important and mathematically beautiful subject. In describing the book as elementary we mean that the author is not concerned with proving his theorems in a highly generalized form and so is able to avoid many of the refined methods of higher anaylsis. However, to read the book understandingly, a thorough grasp of the meaning of partial differentiation and of the definite integral, particularly of line and surface integrals, is necessary; a training in calculus which can hardly be obtained in a first course. Moreover, the reader should be sufficiently mature mathematically to appreciate the importance of an existence theorem.

The first six of the eight chapters in the book deal mainly with the properties of potential functions in general. The last two chapters are devoted to the special functions known as Spherical and Ellipsoidal Harmonics; potential functions which are particularly adapted to the treatment of problems dealing with spherical and ellipsoidal distributions.

G. E. Raynor.

Stuff, The Story of Materials in the Service of Man by Pauline G. Beery, Assistant Professor of Chemistry in Pennsylvania State College. Cloth. Pages xiii + 504. 14x21.5 cm. 1930. D. Appleton and Company, New York. Price $5.00.

Stuff is a series of very interesting stories of the materials used daily by everyone—twenty-seven of them told in the language understood by young America and his parents. Hot stuff, cold stuff, sociable stuff, medical stuff all have marvelous histories. Other chapters almost fascinating enough to compete successfully with jazz for the attention of adolescents are "Textiles from Test Tubes," "Skillets and Skyscrapers," "Gas Bags," and "The Lightweight Champion of the Metals." Nearly a hundred illustrations add charm, interest and educative value to the book. The chapter on "The Structure of Stuff" gives a brief outline of the present ideas of the structure of matter and tells of some of the experiments supporting these theories. Like most of the books on popular science there are some ambiguous statements and some tendency to exaggerate; e. g. on page 350 we find the following: "During this period (1900-1910), aëro clubs became quite common, and ballooning was as popular a sport as motoring is at the present time." But on the whole the facts are accurately recorded, and even though the book seems somewhat sketchy and without plan, it deserves a high rating as a popular survey of the materials in daily use.

G. W. W.

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BROOKLYN, N. Y., U. S. A.

The Essentials of Psychology, by W. B. Pillsbury, Professor of Psychology, University of Michigan. Third Edition. Cloth. Pages ix+466. 12.5x19 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

And now comes W. B. Pillsbury, director of psychological laboratories and head of the department of psychology in the University of Michigan, to reiterate the thesis of functionalism in a day when psychoanalysis, behaviorism, Gestaltism, phenomenalism—not to mention some of the older "isms"—have the public somewhat worried about what is and what is not true among psychologists. The functionalist always has the advantage of being able to say that he presents "the accepted attitude in the science," since most psychologists are still avowedly or covertly followers of William James.

Pillsbury's approach is much the same as in the older edition of the text. Starting with the nervous system, the author passes through sensation, the "native" and the "acquired" in behavior, motor learning, attention, memory, perception, reasoning, feeling, and emotion to the general questions of action and decision, "types of mind," and the problem of the self. Considerable new material is given in the discussion of vision, of memory, of emotion, and of fatigue. The last chapter, historical in nature, is also an improvement on the older edition.

The effect of current researches and theoretical contributions of other than functionalists is evident throughout the book, showing that the author has indeed kept abreast of developments in the field. As is to be expected however, Pillsbury refuses to compromise his original position. He may occasionally raise a question about, or even express satisfaction with, a certain conclusion of a rival theorist, but in the end he inevitably emerges serenely conscious of the correctness of his own viewpoint. This is notably true of the chapters on the nervous system, "native equipment," and perception. Herrick's and Lashley's recent statements in regard to brain localization, Bernard's, Faris', Watson's, Kantor's, and Kuo's writings on the question of instinct, and the generalization of Wertheimer, Köhler, Lewin, and others in regard to perception seem to have left Pillsbury essentially untouched.

Is there no word of commendation then? Indeed there is. As a text for beginners, presented from a consistently functional standpoint, Pillsbury's *Essentials* has probably not been outdone. It is easy to read, well organized, and eminently teachable. The questions, and especially the exercises, at the end of each chapter are exceedingly well done. The chapter on "Types of Psychological Theory" will be appreciated by students at the end of an introductory course.

Maurice H. Krout.

The Teaching of Secondary Mathematics, by Jasper O. Hassler, Professor of Mathematics, University of Oklahoma, and Rolland R. Smith, Central High School, Springfield, Mass. Pages xi+405. 13x19 cm. 1930. Macmillan Company. Price $2.00.

To the reviewer this is the best book on the teaching of high school mathematics that has appeared in the last decide. The authors show in every chapter that they have had a great deal of experience in the classroom, they have the courage to state their views frankly and even to admit in places that some of the fads of our reformers are impractical.

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them according to the teacher's personality and the needs of the class. More than half of the book applies the various methods to the teaching of selected topics of algebra and geometry such as the introduction to negative numbers, the addition of fractions, cancellation, sets of equations, etc. The authors have the courage to say that complex fractions should be simplified by multiplying numerator and denominator rather than by the traditional method of arithmetic, and to say that the substitution method for solving sets of equations is so much more important than the method of multiplying and adding that if only one method is taught it should be the former. The book is full of stimulating ideas; every chapter shows that the authors know what can and what cannot be done in a classroom. Teachers need more books of this kind. Joseph A. Nyberg.

Astronomy by Robert H. Baker, Professor of Astronomy in the University of Illinois. Cloth. Pages xix+521. 15x23 cm. 1930. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Price $3.75.

This book is intended for use as an introductory text for college students. It aims to meet the needs of students who have had very limited preparation in mathematics and physical science. In order to give such students the proper background for understanding astronomical phenomena the author has included a brief discussion of many topics from other sciences; e. g. there are several paragraphs on the atmosphere of the earth, a discussion of the kinetic theory of gases, a paragraph on the refraction of light, topics on the wave theory of light and spectra, and an explanation of the laws of uniformly accelerated motion. The aim has been to make the treatment as nearly independent of mathematics as possible. In many cases the author has found it convenient to introduce mathematical equations and symbols to express his ideas. Since students who have had little mathematical experience are inclined either to pass over such expressions hurriedly thinking they understand them, or to ignore them because they feel that an understanding is beyond their abilities, it would be in accord with good educational practice to include a few numerical exercises based on the principles expressed in mathematical language. Many of these expressions are simple algebraic equations, hence exercises involving them should be within the grasp of any college student. They would give him a clearer understanding of the fundamentals of astronomy and a greater appreciation of the astronomer's work and the way he arrives at his conclusions.

The book is very attractive and profusely illustrated. The language is especially fitted to meet the vocabulary and experiences of beginning students. Like any first edition some errors occur but in general they are minor ones. The discussion is thoroughly up to date both in presentation of new discoveries and in modern views of old phenomena. Chapter X on the constitution of the stars shows the importance of astrophysical research. The admirable chapters on the galactic system and exterior galaxies indicate the rapidly expanding horizon of thought due to recent astronomical research. This textbook will certainly be a favorite in its field and will be a valuable addition to the high school reference library and to the layman's book shelf even though many parts of it cannot be comprehended by the general public. G. W. W.

The Radio Amateur's Handbook, by A. Frederick Collins, Inventor of the Wireless Telephone 1899. Revised and reset (1930). Edited by George C. Baxter Rowe, formerly of the Radio News. Cloth. Pages xxv+368. 13.5x20 cm. Thomas Y. Crowell Company, New York. Price $2.00.

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revision of textbooks is necessary. This is the sixth edition of the Handbook and brings the subject completely up to date. The revision has been very thorough, much of it having been entirely re-written and new cuts added, but it retains the original plan of being essentially a handbook of construction and operation for beginners. Theory is reduced to a minimum. The new chapters contain discussions of A. C. sets, new types of tubes and improved receiving and transmitting apparatus. Attention is given to radiovision and the applications of radio apparatus in the movie industry, aviation, etc. The appendix contains an unusual amount of useful information for radio amateurs.

In his attempt to minimize theory and to reduce it to the level of the beginner the author has sometimes permitted his discussions to become faulty or misleading; e. g. he illustrates "an electric current changed into magnetic lines of force," and states that "electrons are kept in their orbits by magnetic attraction." In the main, however, the context is very reliable and easily understood. It is a book all boys will want. G. W. W.

Manual of Trigonometry for Colleges, Universities and Technical Schools, by E. C. Kennedy, University of Texas, College of Mines. Paper. 107 problems and 3 tables. 21x27.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

Manual of Trigonometry may be used as a work-book in trigonometry. It comprises 126 exercises and 4 pages of tables. Accompanying many of the exercises are well drawn figures. In many instances about one-fourth of the page is devoted to the figure and a statement of the exercise, and the remainder of the page is left blank for work purposes. The manual should find favor with trigonometry teachers who feel that their students are in need of drill on the principles and processes of the subject. C. A. Stone.

WORK BOOKS AND LABORATORY MANUALS.

Unfortunately lack of space prevents publication of reviews of all books received. The following work books and laboratory manuals deserve the attention of teachers in need of such teaching helps:

Laboratory Manual of Physics, by Clinton Maury Kilby, Professor of Physics in Randolph-Macon Woman's College, Lynchburg, Virginia. Cloth. Pages vi+129. 14x21.5 cm. 1930. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Price $1.75.

Especially prepared to meet the needs of the small college laboratory with limited equipment. A companion volume to Kilby's "Introduction to College Physics." Contains 65 experiments.

Exercise and Problems in Elementary Economic Geography, by W. O. Blanchard, Associate Professor of Geography, University of Illinois. First Edition. Paper. Pages vii+48. 21.5x27 cm. 1930. McGraw-Hill Book Company, 370 Seventh Avenue, New York. Price $1.00.

A workbook of unusual value containing seventeen sets of exercises; to be used with an atlas to supplement the textbook and lecture.

A Laboratory Workbook to accompany Chemistry for Today by William McPherson and William Edwards Henderson, both Professors of Chemistry in the Ohio State University, and George Winegar Fowler, Head of the Science Department, Central High School and Supervisor of Science, City Schools, Syracuse, New York. Paper. Pages xii+315. 15x23.5 cm. 1930. Ginn and Company, 15 Ashburton Place, Boston. Price 76 cents.

Written to accompany "Chemistry for Today" by the same authors.

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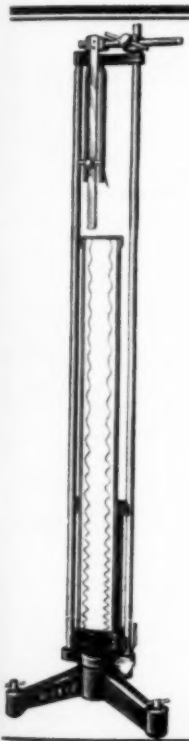

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Work-Text Book in Physics, by A. W. Hurd, Institute of School Experimentation, Teachers College, Columbia University. Paper. xix Teaching Units. 148 pages. 20.5x28 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price 64 cents.

A book which will point many physics teachers to a new method of teaching physics. Nineteen units with questions, problems, suggestions for special reports and projects, supplementary reading references, and a complete set of objective tests. Every high school physics teacher should see this book.

Workbook to Accompany Introduction to Science by Otis William Caldwell, Professor of Education and Director of Institute of School Experimentation of Teachers College, Columbia University and Francis Day Curtis, Associate Professor of Secondary Education and of the Teaching of Biology and General Science, University of Michigan, and Head of the Department of General Science and Biology in the University High School. Paper. Pages x+245. 18.5x26.5 cm. 1930. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price 72 cents.

To accompany "Introduction to Science" by the same authors. Classes using the textbook should also use this workbook. Economical for teachers and pupils. Carefully planned and well written.

Workbook in Plane Geometry, by Hugh D. MacIntyre, Instructor in Mathematics at the Charles E. Gorton High School, Yonkers, New York. Paper. Pages v+121. 20x26 cm. 1930. World Book Company, Yonkers-on-Hudson, New York. Price 80 cents.

Forty units each containing development exercises and problems. Loose-leaf form so blank sheets may be inserted for all written work.

Exercises and Tests in Algebra Through Quadratics, by David Eugene Smith, William David Reeve and Edward Longworth Morss. Paper. 127 tests. 19.5x24.5 cm. 1930. Ginn and Company, 15 Ashburton Place, Boston. Price 40 cents.

127 tests on seventeen major topics.

SCIENCE QUESTIONS

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

WHAT SHALL WE DO THIS YEAR?

Suggestions, please. Thanks! The Editor.

AN ANSWER AND MORE QUESTIONS.

564. *Question:* "What shall we do this year?"

Answer—By Vance D. Brown, Oil City, Pa.

(The questions raised below by Mr. Brown will be published later one by one in subsequent issues of SCHOOL SCIENCE AND MATHEMATICS. Editor.)

409 North St., Oil City, Pa., Nov. 12, 1930.

Mr. Franklin T. Jones,
10109 Wilbur Ave.,
Cleveland, Ohio.
Dear Sir.

In answer to your query, "What shall we do this year?" I offer the following suggestions. I am a new subscriber and it may therefore happen that the material I suggest has already been printed, therefore you will bear with me if I make such requests.

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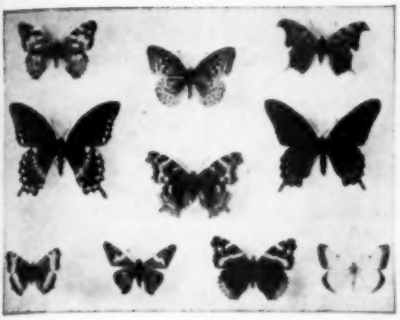

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Suggestions or methods for making glass lantern slides easily and quickly for classroom use.

Suggestive lists of projects for general science project work outside of textbook work, such as building bird houses, making aquariums, etc.

Items relative to practical chemistry. As a suggestion, a certain chemist was riding with an auto driver recently. It became suddenly very cold, and there was no anti-freeze material in the radiator or available. The chemist said to put into the radiator Karo syrup. They drove along a little further and tested the water—it tested good for cold driving. There must be hundreds of simple chemistry ideas and helps here and there if we had them all together. Of course I should like to see the formulas with the articles. Not having studied chemistry, I note the absence of this help.

How to make simple devices to aid the teachers in their classroom, as hectographs, etc.

Trusting I have offered an idea for future help, I am

Yours truly,

VANCE D. BROWN.

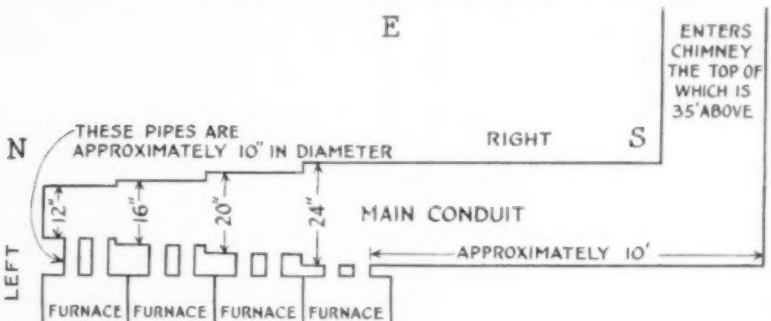
P. S. Has SCHOOL SCIENCE AND MATHEMATICS ever attempted to publish or collect a list of suitable science films for the various science subjects—another idea. V. D. B.

ANSWERS PLEASE TO THE FOLLOWING.

566. *Proposed by Miss Mary Blader, Box 512, Salmon, Idaho.*

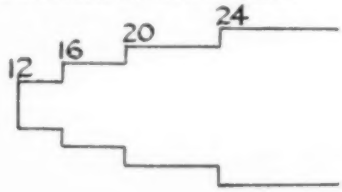
Gentlemen:

I should like to ask your opinion regarding the condition of the draft of the furnaces in our school. Furnace No. 1 (see drawing)



apparently does not have a sufficient draft as it smokes, and the oxidation of the coal is very incomplete.

We would like to know if enlarging the main conduit where Furnace No. 1 enters to the same size as it is on the other end, namely from 12 inches to 24 inches in diameter, would help the draft of furnace No. 1 any? The increases in size from 12 to 24 inches in the main conduit is not rounded off but like this:



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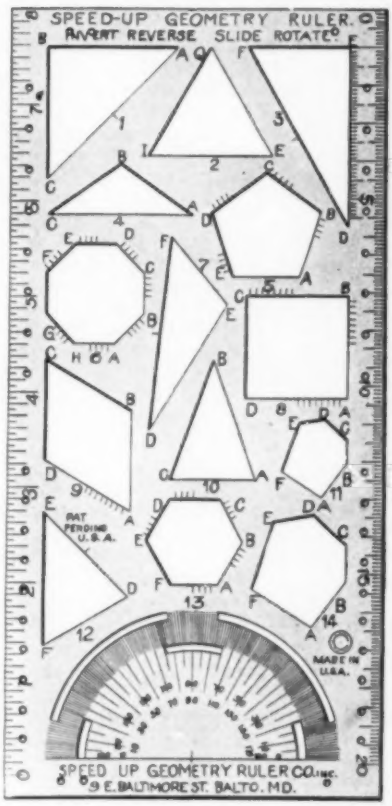
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The top of the chimney is approximately 35 feet from where the pipes leading from the furnace into the main conduit join the lower end of the chimney. Would the draft of furnace No. 1 be materially helped by building the chimney to say 50 feet?

Would air from the fan forced thru the main conduit which carries the smoke away have any appreciable effect upon the draft of furnace No. 1? If so, should this air be passed in to the main conduit to the right of the place where the pipes of furnace No. 1 enter the main conduit, or to the left, in order to secure a more effective draft for furnace No. 1?

ANOTHER QUESTION.

567. *Proposed by Mr. John Skok, Chicago, Ill.*

Mr. Jones:

I have a question in electricity which I would like answered, as I understand you give such discussions in the journal.

In our laboratory work in physics we use a D. C. line which is generated by a D. C. generator in the school. On the switchboard it is marked 110 volts and also 220 volts, although our voltmeter readings are always 110 volts or two or three volts either more or less, but never 220. The switch on the switchboard has three contact points instead of two, and I was told that the P. D. of the middle conductor and an outside one was 110 volts, but the P. D. between the two outside ones is 220 volts. When the switch is closed, all three of these are connected, yet the voltmeter only shows 110 volts.

I don't understand this nor how one generator can generate both 110 and 220 volts at the same time. Why are the P. D.'s always 110 and 220 rather than 100 and 200, or 125 and 250?

I hope you will have time to explain this, and I thank you in advance.

Yours very truly,

JOHN SKOK.

DID YOU KNOW?

That Gordon Highriter's Tests in physics published in this Department of SCHOOL SCIENCE AND MATHEMATICS were translated into French and used as a basis of comparison between French and American Schools?

Would you like to have some of them re-printed in the French? *Please answer.*

JAPAN WILLING TO HAVE WHALING RESTRICTION.

Japan would unite with the United States and any other country to protect the various species of whales for a number of years in order that the mammals might be studied and given a chance to multiply. Japan complains about the continued diminished whale products in her country, according to representatives of fish exporting firms here who sell whale tails and canned whale meat in the orient.

In Japan the gray whale has disappeared. There has been a noticeable decrease year after year of right, fin-back and hump-back mammals found in the sea adjacent to the island empire. Japanese whalers have been forced to take long voyages into the Arctic and far south into the Antarctic to seek supplies for their industries.—*Science Service.*

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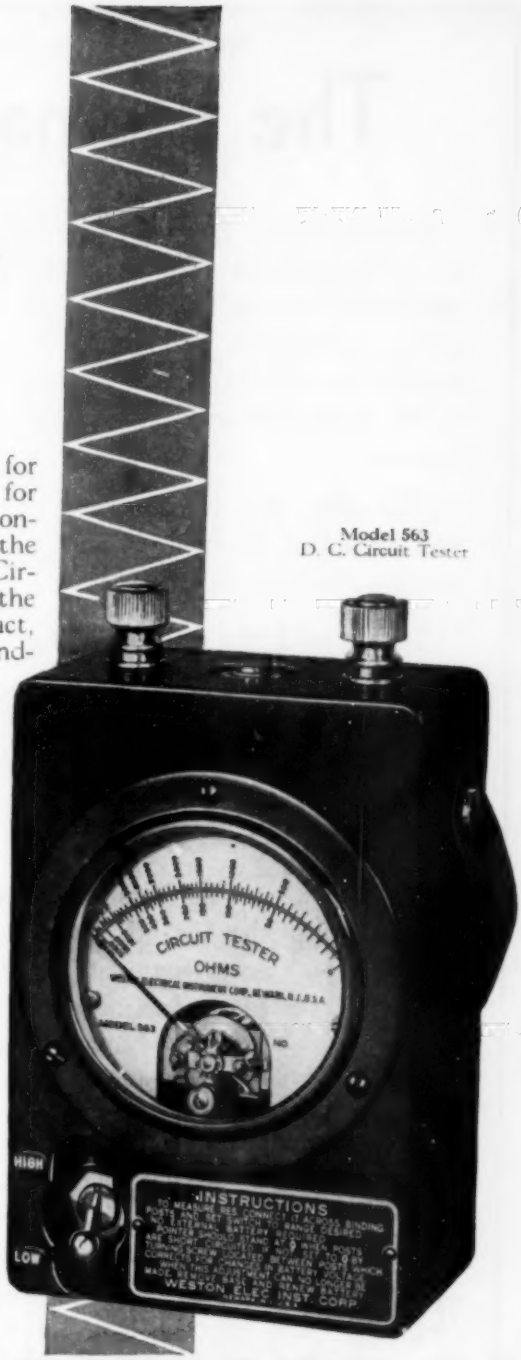

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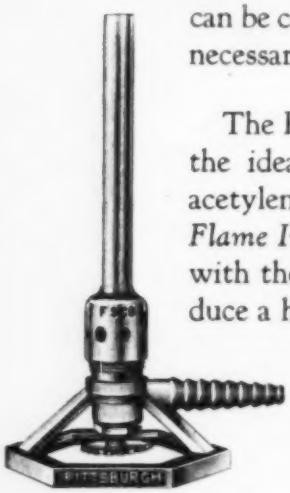

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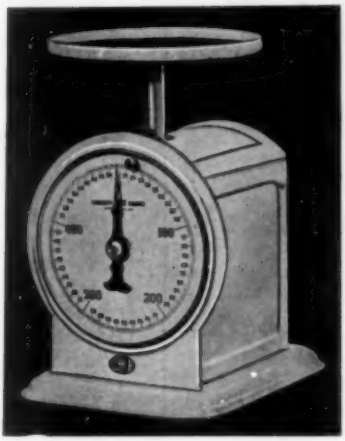

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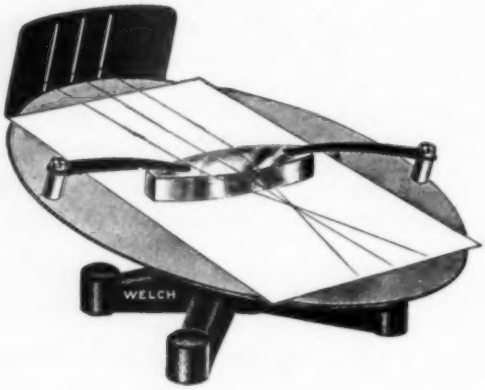

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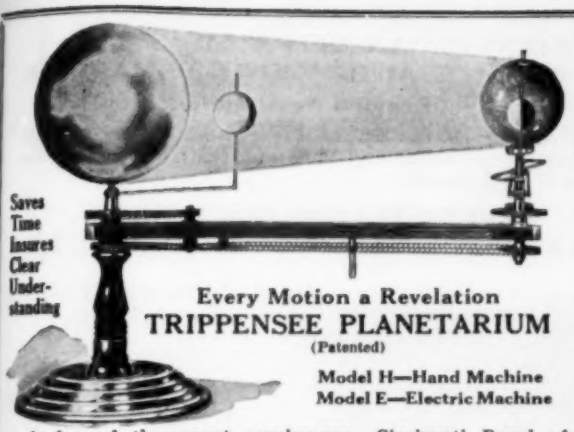

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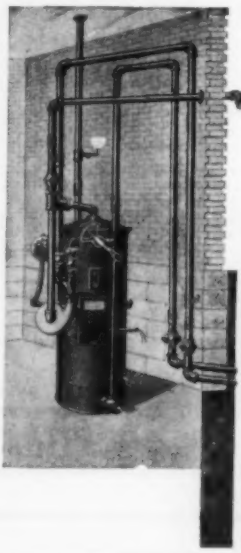

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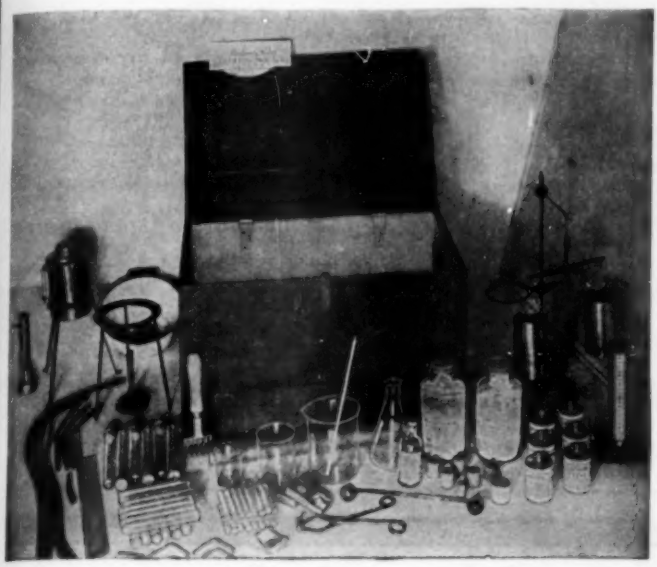

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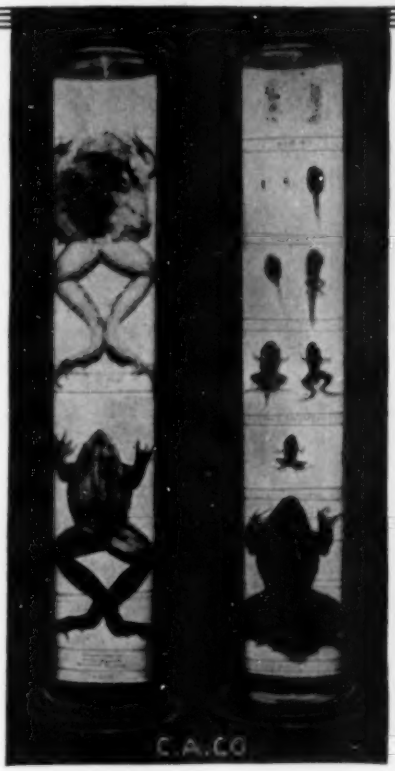

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